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BIOLOGY
IN
EVERYDAY LIFE

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IN

EVERYDAY LIFE

BY

JOHN R. BAKER

AND

J. B. S. HALDANE

LONDON

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PREFACE

THIS book comprises six talks broadcast in the National programme in the Spring of 1933. Conversational English differs markedly from the written language, and it is essential to a good broadcast that the language should be conversational. Indeed, it is almost a criterion of a good broadcast that it should look queer when printed. We have therefore made slight alterations, but we have not rewritten the whole in the ordinary language of print. Certain parts of the book, such as the end of Chapter IV, were not actually broadcast. We wish to express our gratitude to the British Broadcasting Corporation for kindly permitting publication in book form.

J. R. B.
J. B. S. H.

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By

JOHN R. BAKER

University Demonstrator in Zoology, Oxford

CHAPTER I

A Biologist's View of Everyday Life

How much does each of us know about how the world appears to other people? I confess I have not the slightest idea how it appears to a Chinaman, but I am not referring to people of other races. I mean people of my own race who do different things from me. It is often said that we have no idea even how colours appear to anybody except ourselves. Just think of the tremendous amount we do not know about how all sorts of things appear to other people, unless we happen to be extraordinarily imaginative.

About sixteen years ago, when I was a boy of sixteen, I was very keen on the microscopical animals and plants that float about in the sea, and I had an idea that I could invent a better net for catching them than anybody else had invented. To make this sort of thing you want very fine silk netting. Now millers want very fine silk netting, to use in sieves. They call it boulting cloth. So I wrote to a large firm that makes machinery for milling, and got a square yard of it. That is the only object I have ever bought from Mr. C., but every year since then Mr. C. has

sent me a calendar; and every year since I have had a study, it has hung in my study and told me the date. It is not an ordinary calendar at all. On each of its twelve pages are pictures of milling machinery. Every April, amid a maze of complicated machines, I search out and find a little gadget called—what do you think?—a *pritchel.* Sixteen years have gone by. I have grown from a boy to a middle-aged man, and still to this day I do not know what a pritchel is for. It looks uncommonly like a flat-pointed pencil in the picture. If a pritchel is a problem, what of the other objects that Mr. C. shows to me each year? What of this? "One harp or quarter of millstone with ten qrs. running with the sun." I am out of my depth here. The picture looks like a plan of fortifications round a camp. And then a "round bottom tin scoop"? How can one guess its function? Or a "band sack hoist"? Or even a "continuous worm"?

Here is a field of knowledge of which I know nothing, absolutely nothing whatever. You have your field of knowledge, on which you are an expert. I calculate that the chances against your field being biology are about fifty thousand to one, so your *outlook* is almost certainly different from mine. The point of this first chapter is just to show you what it feels like to be a biologist.

Perhaps you will ask why I have let these sixteen years go by and never found out what a pritchel is. That is a perfectly good question and I have a perfectly good answer to it. I have a young friend. When I first met him I asked him what he was interested in. His answer surprised me. "Everything", he said; and so he is. I expect he knows what a pritchel is. But if we try to know about everything, then we can only have a superficial knowledge of everything, and no deep knowledge of anything. Some degree of specialization is absolutely necessary if we are going to find out something new in any department of knowledge, and my object in life is to find out unknown things about living organisms. Of course, it is wrong to specialize too much. I know a man who specializes on cockroaches, and not only on cockroaches, but on the cockroaches of a particular group of islands! A friend of mine says that a specialist is a man who wants to know more and more about less and less. We shall not make any world-shattering discoveries in that way. As in most things in this life, the even mean between the extremes is what we should aim at.

We are all of us rather apt to think that other people's lives and outlooks are rather like our own, until we begin to think seriously about it, and then suddenly we find that we know nothing

about other people's. Charles Darwin, the greatest biologist of all time, spent many years of his life studying barnacles. He had a room in his house where, day after day, he studied his barnacles. That probably seems extraordinary to you. But did it seem extraordinary to his family? Let me tell you. His family were one day shown round a friend's house. We will call the friend Mr. A. The hall, the dining-room, the drawing-room, and no doubt the various domestic offices were reviewed in turn. One of Darwin's little boys was there. The house would have seemed a very ordinary house to an ordinary boy, but to Darwin's boy it seemed an extraordinary house. When they at last left to go home, he could contain himself no longer. "But mother", he asked, "*where* does Mr. A. do his barnacles?" Darwin's son had accepted the "doing" of barnacles as a natural part of every grown man's existence.

I am not going to say what it is like to work at barnacles, or even to work in a laboratory at all, but I want to give you some idea of what it feels like to be a biologist. Probably you think biologists are very funny—even extraordinary—people: and probably you think that they are concerned with things that don't matter a bit. Often things which do not matter at all at the time they are discovered become extraordinarily important a generation or

so later. What about the man who was studying the reproductive organs of grasshoppers and discovered the secret of sex determination? One day fairly soon the world may be topsy-turvy as a result of that discovery. Our newspapers are full of politics, politics, politics. It cannot be very long now before ordinary politicians take their proper places in the background, and biologists begin to control human life. Already this great revolution is beginning. I am reserving all that for later chapters. In this first chapter I am asking you to allow me to introduce myself and show you how the biologist is alive to everything that is going on around him, and alive in a special way.

Well, then, the biologist awakes in the morning!

I am awakened by the pulling of blinds. I am dimly conscious of my housemaid's movements about the room. She has got up before me and now she is doing things for me. Why? Is there anything like that in the animal kingdom?

Certainly there is. There is even the exact counterpart of complete slavery. There is an ant called *Polyergus rufescens*, which is common in parts of Switzerland.[1] The workers are very ferocious and never look after their own young, as the workers do in all ordinary kinds of ants.

[1] See Wheeler.

What is more, they are not even capable of collecting their own food. How do they manage to exist, if they cannot look after themselves? They enslave other kinds of ants, especially one called *Formica fusca*. Usually there are about six times as many Formica as Polyergus in the nest. Each Polyergus has half a dozen slaves to look after it.

The slaves are workers, which do not breed. In time they die off, and if they were not replaced, the poor Polyergus would be as helpless as I should be if my cook and housemaid and nurse were suddenly to desert me. But there is just one thing that Polyergus can do, and that is to get more slaves from time to time. In the summer small parties of Polyergus go off and look at the Formica nests in the neighbourhood. Then one afternoon in July or August all the Polyergus ants in the nest march out together in a dense column. They go straight to one of the Formica nests. It is exactly like an Abyssinian slave raid. It looks as though they had investigated all the nests round about and for some reason chosen this special one for attack. If the nest is defended, they kill the defenders with their huge jaws. They carry the pupae back to their own nest. In due course the pupae change to adult ants, which accept the Polyergus nest as their natural home,

and spend their days slaving for their masters. The architecture of the nest is exactly that of the slave ants. Their masters cannot even excavate a nest.

We have not got far with the day yet. I have just woken up. From my bed I can see the basket in which my dog, Merry, sleeps. I keep him just as a pet, and because I like him. He is of no use whatever. He is a cocker spaniel, but I do not shoot. If a burglar were to come, he would be almost certain to go up to him and lick him. I keep him simply as a pet. I like patting him and talking to him and taking him for walks. Do any other kinds of animals keep pets?

There is a minute beetle called Hetaerius that lives in ants' nests in Europe and North America. Hetaerius does nothing whatever to help in the economy of the ants' nest. Yet the ants feed him: in fact, he relies entirely on being fed by the ants. Why do the ants tolerate him? Simply because they like petting him. The ants lick him all over the face, and appear to enjoy doing so. When they start trying to lick his face, he pulls his head back under his thorax, and the ant cannot get at him properly. So the ant throws up some of the contents of its stomach, which the beetle likes to eat. Directly the beetle puts his head forward to eat, the ant starts licking its face

effusively. After a bit the beetle often pulls his head back again, and the ant has to produce some more food to induce it to allow itself to be fondled again. The ants like carrying the beetles about and also roll them over and over like barrels. So it is not only human beings that like pets.

One of the first things I do is to put on my spectacles, as I am shortsighted. That is to say, the lenses of my eyes are of the wrong shape. It is rather annoying to remember that they produce a perfectly good image of everything, but in the wrong place. Instead of producing the image on the backs of my eyeballs, where the sensory cells are that would convey the image to my brain, they produce it in front of them, where there are no sensory cells. If I put concave spectacles in front of my eyes, the image is thrown back on to the right place and I see clearly.

The frames of my spectacles are partly of what is called tortoiseshell, but tortoiseshell is not actually the shell of the tortoise. It comes from the hawksbill turtle. Turtles, of course, have paddles. Tortoises have separate fingers and toes. The turtle that produces tortoiseshell is not the same as the turtle which finds its way into soup. The tortoiseshell turtle eats fish. Like most carnivorous animals, it is not very good to eat. The turtle which we eat eats seaweeds.

I must get up and have a wash. Here is my sponge. I propose to wash with the skeleton of a marine animal. There is not any doubt the sponge is an animal. Plants are living organisms which can live on inorganic salts, or are obviously related to ones which can. Animals are living organisms which require organic matter ready made for them. They either eat plants, or else they eat animals that eat plants, or eat animals that eat animals that eat plants, or at any rate somehow or other get organic matter that was made from inorganic salts by plants in the first place. A sponge feeds on microscopic plants and animals which float about in sea water. It is really a sieve through which the water is passed by the lashing of microscopic whips. The thing we wash with is just the skeleton of it. There are hundreds and hundreds of different kinds of sponges, but only a few of them are any good for washing. Most of them have masses of hard pointed spicules in them, and they would be most uncomfortable things to put against one's skin.

Then what a remarkable process shaving is! To the biologist it presents all sorts of problems. Why do hairs grow on my face? One knows this much. There exist certain glandular cells in the reproductive organs of men, which make a chemical substance and push it out into the

blood. It circulates in every part of the body, and makes the different parts grow in the male way. The substance is what is called a hormone, or chemical messenger. That is a partial explanation, but it does not explain the use of a moustache and beard. We call organs of this sort secondary sexual characters. By that we mean that they are not essential sexual characters in any obvious way. The wattles of cocks are an example. They are supposed to be an attraction to the female, and Darwin thought that in the course of evolution they gradually got bigger and bigger because the hens tended to choose for mates the males with the biggest wattles. But beards! Most men seem to get chosen all right without them. They are a bit of a mystery to the biologist. Perhaps they were an attraction to the female of our pre-human ancestor, and we have simply retained them, while women have changed their opinion as a result of education. If a modern English girl were cast up as a baby on a desert island and managed to survive, what would she think if she were brought to England? Would she fall for the first bearded man she saw? I wonder.

Many men think the hair on their faces grows more quickly if they shave than if they do not. Recently a woman in America got four men to send their shavings to her over a period of nine

months, and she made elaborate measurements of them. Sometimes they shaved every twelve hours, sometimes they went four days without shaving. It made no difference whatever. The hair went on growing at the same speed whatever they did.

When I want to shave, I have got to have a foam of bubbles to support the hairs while they are being cut, and a slippery fluid to let the razor slide along easily. Soap does the trick. It is an extraordinary fact that for making this slippery foam there is nothing so good as the hair of the badger.

Have you ever seen a badger? One does not often see one, because they are nocturnal. They live in holes. Some people think it fun to pull them out of their holes with specially made tongs and then kill them. One must have an extraordinary idea of the meaning of words if one calls that sport. Badgers are most interesting animals in several ways. Their long hair seems to be a protection against attack as well as against cold. Wherever one catches hold of a badger, he seems able to bite. That is partly because his hair is so long, and partly because his skin is so extraordinarily loose. He can turn inside his skin, so to speak. It seems rather extraordinary that a structure that has evolved for the purpose of protecting the badger and keeping him warm

should be found to be the best possible instrument for making a lather with soap.

People often think badgers are closely allied to bears, but that is not so. They come in a group with the stoats, weasels, otters and skunks. They all agree in having very few molar teeth, that is, teeth behind the ones that replace the milk teeth. Bears have two above on each side, and three below. The stoats and badgers never have more than one molar tooth on each side in the upper jaw, and only one or two below. We have three, of course, both above and below, the last being the so-called wisdom-tooth. Lots of animals have three, but it is rather unusual for animals to have only one, both above and below, like many of the badger's relations.

Well, we have got on to teeth, and now that I have shaved I must wash them. Is it not extraordinary that we have to wash our teeth to keep them in good condition? We seem to have the worst teeth in the animal kingdom, and fossils of our prehuman ancestors show that they too suffered from dental decay. I wonder why it is. One has the impression that our teeth are often too crowded in our mouths. If only they were better spaced, like most animals', food would not get stuck between them, and then probably they would not decay so fast. Why should our teeth

be so crowded? I wonder if it can be that they did not get proportionally smaller while our jaws were decreasing in size. There is no doubt that our ancestors had much bigger jaws than we. They stuck forward something like a gorilla's or chimpanzee's. Nearly all the fossil skulls of our remote ancestors show that. (Actually I should say the relations of our remote ancestors, because of course there is no evidence that any of the fossil skulls really represent actual ancestors of modern man.) The aborigines of Australia still retain the large jaw, but it is not nearly so prominent as those of the fossil skulls, and theirs are not so prominent as the gorilla's.

Let us get dressed. Do any animals dress? That all depends on what one calls dressing. By dressing, I mean putting a bit of the environment on oneself for protection. Certainly there are animals that do that. The caddis-worm is an obvious example. You have probably seen him. He lives at the bottom of ponds. He is the larva of the caddis-fly, but you do not often see caddis-flies. That is because caddis-flies are dull-coloured and do not often fly about. They prefer to remain hidden. The larva or caddis-worm takes tiny bits of vegetable matter or grains of sand and makes a little tube out of them in which he lives.

My clothes are sewn together. The caddis-worm does not exactly sew, but there is a tropical ant called Oecophylla which practically sews. I really think that Oecophylla is one of the most wonderful animals in the whole of nature. It does not sew to make clothes, but to make its nest. It makes its nest of leaves sewn together at the edges with silk. Now no adult insect[1] makes silk, though insect larvae—that is caterpillars—often do. The larvae of Oecophylla make silk. They make it in two glands in the abdomen and it oozes along a tube in a sticky condition and finds its way out by a pore on the lower lip. Ant larvae are absolutely unable to move about and could not possibly sew with this silk. What is the use of it? What I am going to tell you is practically unbelievable, but it is true nevertheless. To make a nest, a row of ants holds the edges of two leaves together. Then other ants line up on the other side of the leaves at their junction. They actually sew them together, holding the leaves in their jaws and passing the larvae to and fro across the gap. They use the larvae as living reels of silk. The silk sticks to the leaves where it touches them.

Now brushing the hair. My hair is quite short. That is because I get it cut every now and then. Does any animal besides man have the habit of

[1] Except the fly Hilara.

cutting bits off itself? The Motmot is a bird something like a kingfisher. He lives in Central America. He has an extraordinary habit.[1] He nibbles off the barbs of his middle pair of tail feathers all the way along except just at the tip, where he leaves a racket-shaped end. All along the rest of the feather he leaves nothing but the bare quill. I say "he", but actually both sexes do it.

I do not only brush my hair; I also comb it. Animals, too, sometimes have combs. The middle toe of the nightjar is like a comb, and he is thought to arrange his feathers with it. Gannets and herons have a similar arrangement. Then there is a curious Malayan mammal called Galeopithecus. He seems to be allied to the insectivores, the mole and shrew and their allies, but he is bigger than these, and he has got a membrane stretched on each side between his arms and his legs, so that he can glide about from tree to tree. Galeopithecus has a comb. His lower front teeth are comb-like. They are really very extraordinary to look at. Perhaps you could see them in a museum, if you happen to live in a big town.

Combs are sometimes made of tortoiseshell, and sometimes they are synthetic, but often they are made of whalebone. What is whalebone? First of

[1] O. Salvin, *Proceedings of Zoological Society of London*, 1873 (p. 429).

all whalebone is not bone. It is a horny substance. It is produced by the toothless whales only. It hangs from the roof of the mouth in ridges. The lower edges of the ridges are frayed. The whale fills his mouth with water, and then raises his tongue. In big specimens his tongue may weigh a ton. When he raises it, the water is squeezed out between the frayed ends of the whalebone. The minute floating animals in the water are held back by the whalebone, which is really a sort of filter. He licks them off and swallows them. It seems extraordinary that such a huge animal should feed on almost microscopic food, and perhaps even more extraordinary that the substance which has evolved to act as a filter for the whale's food should have been found to be one of the best substances for preventing human hair from getting tangled.

If I were to go right through my day, it would take many chapters, but we have more serious business to which to attend. This is really just an introductory chapter, to give an idea of a biologist's outlook on things in general. In the next chapter we shall discuss social animals. Man is essentially a social animal. We must study social animals in some detail first, so that even the second chapter will be to some extent introductory.

CHAPTER II

Social Life in Animals

WHAT is the greatest feat of heroism that you have ever heard of? I suppose that heroism usually consists in disobeying a strong instinct for some worth-while object. Usually it is the self-preservation instinct, I suppose, to which the hero is superior. What do you yourself regard as the greatest act of heroism? I know what I think, and the ordinary self-preservation instinct was not concerned. My hero rose superior to the *herd* instinct. Mr. Courtauld went into the interior of Greenland with a party, and then remained there when the party returned to the coast. He remained there throughout the black Arctic winter absolutely by himself, with not a single human being within 120 miles. He completely disobeyed one of the strongest instincts we have, for the sake of making observations on the weather in a place where practically nothing was known before.[1]

Have you ever been alone? How far is the farthest you have ever been from any other human being? And how long did you remain at this distance?

[1] *The Polar Record*, No. 4, July 1932.

We are so obviously social animals that we do not often bother to think about it, or to ask ourselves whether many animals are like ourselves in that respect, or whether perhaps it is rather an unusual phenomenon in the animal kingdom.

Let us look at the minutest animals of all first, the little very simple beasts that swim about in ponds and which we have to use a microscope to see at all. Most of them are not social: I mean they do not depend on others of the same sort as themselves. They multiply by dividing into two. Each soon grows the missing part. They are so simple that that is not difficult. In the higher animals that would be obviously impossible, because neither half could get on for a moment without the other. Even if each had the power of growing the missing bit, it would not be able to, because it would be dead from loss of blood before it had time. Each of these little beasts is only a speck of living matter, with nothing like blood and no complicated organs, so things are easy for it. After dividing, the two new individuals separate and swim away and go about their own businesses and pay no attention to one another. There was one individual, and now there are two: that is all.

Now some species do not behave like that. When one divides into two, the two do not separate, but stick together. Each of them

divides, so now there are 4, and when they divide again there are 8, and they still stick together and go on dividing. Soon we have 16, and then 32 and 64 and 128 and 256 and 512 and 1,024 and 2,048. We are into thousands at the tenth division. The little beasts are growing all the time. Well, you will say, we shall be able to see it soon. Why have we not all seen one of these creatures? Wait a moment. Perhaps you have. Fifty divisions give us countless millions of little beasts, and even if they are very small, the total size must be quite great. Do all the little beasts look exactly the same? They do not. The ones on the outside become flattened and horny. The ones right in the middle form themselves into a tube, and they are the ones that are the best at eating. They do enough eating for all the other ones put together. They are protected from harm by the horny ones on the outside, and in exchange they give up some of their food to the horny ones. The two sorts help one another. Another sort makes a hard substance which gives the whole collection of them a certain amount of strength; and others are especially good at contracting, and they enable the whole collection to move about and get food and escape from enemies. What a wonderful collection of little beasts, all being so self-sacrificing! Not one is working

just for itself. They all work for the common good.

Are these wonderful collections of little beasts very rare? If we hunt for them, shall we be able to find one and study it? Where shall we look?

Do not bother to look. You *are* one yourself. That is all you are—nothing else. If you did not mind me hacking you about, I could take a little bit of any part of you and show it you under the microscope, and you would see the tiny beasts which compose you.

So you see, in a sense you are not an individual, but a mass of millions of individuals and nothing else. We may call you an individual of the second grade, made up of millions of individuals of the first grade. Nearly always all the tiny individuals work together for the common good of the second grade individual, but just sometimes some of them in one part begin multiplying indefinitely, and will not stop, and these ones do nothing for the common good. On the contrary, they poison it. Then we have cancer. Luckily the rays given off by radium check their multiplication.

We have studied two grades of individuality. Are there any more grades?

Take the sea anemone. It is an animal that lives in rock pools round our coasts. There is a circle of tentacles round the mouth and often they

are of bright colours. These are individuals of the second grade like you and me, but in the tropics there are anemones that divide into two, and the two into four and so on, until there are hundreds or thousands. They do not separate from one another. They remain attached like super-Siamese-twins. Their insides are connected, too, and so one cannot starve while another has food. They all together make a single solid rock-like skeleton. We call the whole mass a coral. It may be yards across. It is an individual of the third grade.

We can extend that term a bit. Supposing the anemones separated from one another, but still remained in a group and helped one another in some way. Should we be able to talk about the third grade still? I do not see why not, so long as the whole group worked together for the common good. This sort of third grade individual is not rare in the animal kingdom. A hive of bees is an example. An ants' nest is an even better example, perhaps, because ants have carried the thing farther than bees. In a hive of bees you find males, females and workers, but in an ants' nest you may find males, females and more than one sort of worker. When I say more than one sort, I do not mean simply that some of them specialize at one thing and some at another. It is not just that. Their bodies are specially constructed for the

particular work they have to do. Among many kinds of ants there are ordinary workers and also soldiers. The ordinary workers do the ordinary work of the nest, such as carrying pupae about and getting food. They are ordinary looking ants. The soldiers are most extraordinary looking ants. They are much bigger than the ordinary workers, with a head that is disproportionately enormous, with huge savage jaws in front. The soldiers' job is to guard the nest from attack.

That is interesting; but here is something ever so much more so. In the honey ants the ordinary workers do all the ordinary work of the nest, and also collect a sugary fluid that exudes from oak galls, and another sweet fluid called honey dew, which is produced by plant lice. The ants stroke the plant lice with their feelers till they exude it from the hind end of their body. The workers then eat it. Many sorts of ants do that, but the honey ants now behave in a most extraordinary way. They go home, and enter special chambers in the nest, where an extraordinary spectacle presents itself. These special chambers have smooth floors and walls, but the ceilings are rough, and to the ceilings a large number of ants are attached. Ants, I say, but you certainly would not call them ants unless you knew, because they look much more like little footballs. Their abdo-

mens are tremendously swollen, and the thorax and head look like little after-thoughts attached at one side. Those repulsive abdomens are stuffed full of the sweet fluid that the ordinary workers bring back. When they come back, they approach the living jam-jars and vomit, and the living jam-jars eat the vomit and grow even fatter still. They can move a little about the ceiling, but if they lose hold and fall to the floor, they are so fat that they cannot get up to the ceiling again. There they stay, some hundreds of them in a big nest. They may live there for years. If there is a period of food-shortage, all the ants of the nest come and cause them to vomit in their turn. That is the use of them to the nest as a whole: they are living food-stores. It is not certain whether all the worker ants in the nest have the capacity to swell and become food-stores, or whether some of them are from the beginning different from the rest.

Among the backboned animals there are plenty of social kinds, but there are not any cases of different types within a single kind, except so far as the male is different from the female. There is nothing corresponding to a soldier ant, which is structurally adapted to its special job.

Among the mammals the most obviously social are the marmots, beavers, vizcachas, horses, deer,

oxen, antelopes, sheep, goats, porpoises, dogs and wolves, seals and sea-lions, fruit-bats, many monkeys and man. What advantage do they get from being social? In the great majority of cases the advantage is simply protection from flesh-eating enemies. Often they have ways of warning one another of the approach of danger. You have probably heard rabbits stamping with their hind feet for that purpose. Among antelopes definite sentries are set. While the herd as a whole is feeding in the open, one or two individuals mount guard on any suitable little hillocks and keep a look-out.

In social animals an instinct to keep with the herd is absolutely necessary. The way sheep follow one another unquestioningly is proverbial. We are social animals ourselves, and in crowds we are extraordinarily easily led to follow one another, to do things which we would not think of doing if we were by ourselves. In America whole crowds go off to prisons and drag out negroes who have not been tried for any offence and hang them. We see here the herd instinct at its worst. If you took those lynchers separately, you would find that nearly every one of them wanted the negro to have a proper trial. Yet in a crowd they all are raving mad to kill him.

The herd instinct has both its bad and its good

side. Altruism only occurs in social animals. Altruism is an action for the benefit of other members of the same herd, and morality is, or should be, based on it. Altruism satisfies our herd instinct, and therefore makes us happy, just as the satisfaction of other instincts does. Some people have scarcely any of this instinct, and are absolutely selfish. These people sometimes argue that no one ever does an unselfish act. They say that every apparently unselfish act is done so as to get some benefit in a roundabout way. That is just nonsense and ignorance: a certain amount of altruism is instinctive in normal people.

The herd instinct makes us like to be in crowds. Probably television will one day enable us to have cinema shows broadcast to us in our houses, but I am sure most people will still flock to cinemas, for the sake of the satisfaction they get from being in a crowd which is swayed by the same emotions.

I have said that the advantage of being social is usually protection against enemies, but of course that is not so with the dogs and wolves. With these carnivorous animals the advantage is that they can attack animals which are far too big for one of them to attack alone. It is rather curious that societies for the sake of offence are rare. Also it is curious that such a close relative of the dog as

the fox should be completely non-social. The advantage of the dog as a pet is simply due to its herd instinct. It attaches itself to its master as it would to the pack in the wild state.

A large herd cannot act together for the common good unless there is some leader to follow. Among wild dogs and wolves the leader is always an old male. The younger males want to be leaders also, and fight him for the leadership. He holds on as leader so long as he is the strongest; but when he gets old, he is beaten in a fight, and a younger male takes his place. This is probably quite an effective system, because a dog that is good at fighting will probably also be good at hunting the animals on which the pack feeds.

Now let us look at a few other social animals. Let us look at the vizcacha first. This is a rodent which lives in South America. It is not absolutely unlike a rabbit with short ears and a bushy tail. It lives in villages of twenty or thirty members. There are about a dozen burrows in the village, and all the burrows intercommunicate underground. Like most social animals, vizcachas talk to one another a good deal. Of course, they have not got a proper language, with words denoting definite things, but they make a great variety of sounds. No doubt this helps to keep the herd together. A sudden change in the sound would

indicate alarm, and all could escape into the burrows before most of the members of the village had any idea what the danger was. Like other social animals, the vizcacha is altruistic. If one of the community is carried off by a peccary (a sort of pig-like animal that lives in South America), its friends try to rescue it.

Occasionally a new village is formed. Hudson[1] says that the vizcacha that founds a new village is always a male. He goes and digs his burrow in a new place, away from any other village, and later gets a female to live there with him. As the family grows, a new community is gradually built up.

We have seen that a male is the leader of the pack of wild dogs and the founder of a new village among the vizcachas. Is the male always the leader among social animals? Certainly not. Among red deer the herd is led by an old female. The old males lead a non-social life. In the mating season the herd breaks up. The males fight for the possession of the females, but there is no fighting for the leadership of the herd.

The female often has duties that one might not expect of her. People often imagine that it is a sort of law of nature that the female is the weaker and more timid sex. That is absolutely untrue. It

[1] W. H. Hudson, *The Naturalist in La Plata*, Dent, 1903.

is the female lion that teaches the young to hunt. In spiders the female is often the larger sex, and in many species it is the rule that directly after courtship she kills and eats the male. It is not at all an uncommon thing for the female to be the larger sex. This is especially so among the savage birds of prey, for instance, the kestrel and golden eagle. The female sparrow-hawk is much larger than the male. It is said that if a pair of goshawks is caught and put in a cage, they always fight, and the female always kills the male.[1] The phalarope is a northern wading-bird. The female is both larger and more brightly coloured than the male, and takes the more active part in courtship. It is the male that sits on the eggs.

In the most diverse groups of the animal kingdom we come upon species in which the male is minute compared with the female, and parasitic on her. There is a marine worm in which the female is about the size and shape of a plum, while the male is about a twentieth of an inch long and lives inside her kidney. Then there are the oceanic angler fishes. If you live in London you can see splendid models of them in the main hall of the Natural History Museum at South Kensington. The male is a tiny little object which

[1] R. Lydekker, *Wild Life of the World*, Vol. I, Warne, London (no date).

attaches itself to the skin of the female by its mouth and never lets go. It actually fuses with the flesh of the female, and is nourished by the foodstuffs circulating in her blood.

Perhaps it is not beside the point to mention the otter. The young are not instinctively aquatic at all. They are forced into the water and taught to swim and catch fish by the female. The male takes no part in their education.

Now we must get back to our social animals again. I only wanted to make it clear that the superiority of the male sex is by no means a law of nature, and we must not be surprised when we find a female leading the herd in a social species.

Social animals can work together and make things that solitary species never could. The beaver is the best example. The beaver is a gnawing animal—a rodent—rather more than three feet long, counting his tail. His tail is flat when looked at from above. He has thick brown fur. He eats the bark of trees. He is very clumsy on land. He always likes to be near a stream, because he is extremely agile in the water, and can easily escape from his enemies, the bear and wolverene. Now, streams have a way of drying up in North America, where he lives. So what does he do? He helps to do something that he could never do

by himself. The whole community works together and builds a dam across the river, to keep the water permanently at a high level. They cut down trees by gnawing through them near the base, and then cut off the branches and cut the trunks up into convenient logs. If the trees are close to the river, it is easy for them to transport the logs to the site of the dam. If there are no trees close to the river, they make a canal from the river to where the trees are, and float the logs down it.[1] They build the dam of logs and mud, weighting it down with heavy stones.

There is one special reason why they want to have deep water always, and that is to keep their front doors under water, so that no land animal can enter their houses. Their houses are great rounded domes, about eight feet high and as much across. They are generally on the river bank, sometimes partly submerged. They are made of branches plastered together with mud, and the walls are so thick that the space inside is quite small. The passage from the house to the submerged front door may be thirty feet long.

When a beaver is alarmed, it does something which is not of any use to itself, but which helps the other members of the community. It gives the

[1] V. Bailey, United States Department of Agriculture, Bulletin No. 1078.

water a resounding slap with its flat tail, and the noise warns all the others to dive for safety. Its instincts are designed for the preservation of the community of beavers as a whole.

Let us now take an animal that is interesting in quite a different way. It has no remarkable social instincts, but it is necessarily social from its abundance in the places where it lives. Probably you have never seen a lemming, but if you live in the country you have no doubt seen a short-tailed field mouse, and the lemming is like that, only a good deal bigger and much fatter in proportion. He lives in the high plateaux, up above the limit of the coniferous trees, in grass-land with birch and willow. He eats grass chiefly, and the people who live down by the coast do not see him. But he multiplies and multiplies, and he gets too numerous for the amount of grass that there is on those mountain wastes. If only he would reproduce more slowly, all would be well, but he does not: he breeds as hard as ever when he is already getting too numerous. Indeed there is some evidence that he breeds harder than ever at that time. Poor fool, he does not realize what is in store for him. If lemmings could moralize like human beings, I dare say there would be many good old-fashioned ones who would say they liked to see lemmings with a good quiver-full,

whatever that may mean. Perhaps if they could take photographs, a signed photograph of *il Duce* among lemmings would be awarded to the mothers of more than a certain number of young. Anyway, they act as though they had some such stimulus to fertility.

At last there is no more grass left—nothing whatever to eat. This timid, secretive, mountain animal is forced by hunger to forsake its home and emigrate. In countless thousands they swarm down the valleys, ever westward to the lowlands and the sea. Their emigration is useless, but they are driven to it by hunger. They swarm across rivers and through villages, and all timidity is lost. Though excessive breeding is the cause of their trouble, they breed as they go. Infectious disease is rife in the overcrowded swarm. Foxes, hawks and owls congregate round the emigrating hordes and feed upon them. Onward they go, farther and farther from the mountain plateaux above, the only region where they can live permanently. At last they come to the sea. Plunging into it, they swim out to their death. As though the water were not enough punishment for their folly, the gulls attack them. A ship may steam for a quarter of an hour through an army of millions of lemmings. They may reach an island and gain temporary respite, but on they go into the sea

beyond. Not one returns. Every emigrating lemming dies. The offspring of those which breed on the way die also. The whole venture is useless.[1] It is caused by over-population. If breeding had been slower, there would always have been plenty of food for all.

Up in the mountains there remains a minute number of lemmings which have never emigrated. What they find to feed upon is not known. Presumably they must be near starvation until the grass has had time to grow after the great exodus. Next year the number of lemmings increases. Four years after the year of the great exodus the numbers are once more enormous. Rapid breeding continues and the emigration is re-enacted. The interval between one emigration and the next is not always exactly four years, but it approximates to that.[2] It is not always a huge emigration: the size of it varies. But three times every dozen years the lemming gives us a practical demonstration of the folly of unregulated reproduction.

Why do not all animals have the same trouble as the lemming? If no house-sparrow died except from old age, in a quarter of a century we should not be able to see the ground anywhere. It would be completely carpeted with house-sparrows, and

[1] W. Heape, *Emigration, Migration and Nomadism*, Heffer, 1931.
[2] C. Elton, *Animal Ecology*, Sidgwick and Jackson, 1927.

we should not be able to take a step without walking on them. Yet on the average their numbers remain the same from year to year. It is clear that they are dying off in great numbers all the time, and that their rate of reproduction just suffices to balance the loss. What would happen if we started a Sparrow Protection Society, and made sure that none died from cold or from the attacks of enemies? The number of sparrows would increase and increase until it became so great that suddenly the food supply would be insufficient. Suddenly there would be starvation on an appalling scale, and sparrows would stand a good chance of being nearly exterminated by misplaced kindness. If we really wanted to protect sparrows, our Protection Society would have other functions beyond applying electric warmers to their sleeping places and exterminating their enemies. I fancy that an army of birds' nesters would also have to be engaged to remove an egg or two from every sparrow's nest.

This is not just wild speculation. In the old days deer lived and maintained a normal population in North America. They were eaten by the mountain lion, and their natural rate of increase was sufficient to make good the loss. In one of the American national parks the mountain lion has been practically exterminated by man. That must be nice for

the deer, you will say. The deer multiplied till there were about 30,000 of them in the park. Every scrap of grass was eaten. The trees were everywhere browsed upon as high as the deer could reach. Then—starvation.[1]

So far as man is concerned, can we draw any conclusions from our study of social animals? Firstly, we will do well to recognize the herd instinct. We should allow ourselves the full satisfaction of obeying it whenever our reason tells us that it prompts us to act for the benefit of the community as a whole. We can see, though, that in animals the instinct is sometimes perverted in an extraordinary way. Sometimes it is a harmless perversion, as when a whole flock follows its leader to do a stupid thing. If we think, reason will tell us not always to follow stupid leadership. But sometimes, in animals, the perversions of the herd instinct are ugly. A wounded cow is often attacked by one of its own herd, and then the others join in, and the wretched beast is gored to death. We see the same hideous sight in the lynching of down-and-out negroes in the United States of America, and in the travesties of justice such as the Scottsboro' case.

Can we learn any lesson from the lemming? We can, but shall we?

[1] M. A. C. Hinton, *Proceedings of the Linnean Society of London*, 144th Session, 1931–2 (p. 111).

CHAPTER III

The Determination of Sex

It's not much fun being a biologist! The trouble is that everyone else knows better. I wonder why poor biologists have been singled out in this way. Why not chemists for a change? Chemists are absolutely immune. No one thinks he knows better than a chemist. If a chemist says that rosaniline is made by the reaction of one molecule of aniline with one of orthotoluidine and one of paratoluidine, he is not contradicted. No one writes to the newspapers and says he can make rosaniline out of ink and sawdust. It just does not happen.

Perhaps it is partly because chemistry is written in awful symbols which frighten people off the subject. If so, I almost wish we had as many signs and barbarous words in biology, because it gives one rather a pain to see well-meaning people writing pure nonsense about biology in newspapers. They even write books on the subject that are a living advertisement of ignorance from beginning to end. Of course everyone *must* be ignorant of whole fields of knowledge, but it is a mistake to lay down the law on subjects of which one knows nothing.

There are branches of biology that are immune. No one writes to the newspapers about the development of the chondrocranium in elasmobranchs. But there are large departments of biology that are considered fair game. Evolution is one. There is one subject that ignorant people have fastened on to more than all the others put together, and that is the determination of sex.

People often say, "Everyone is entitled to his opinion," and so he is so far as insoluble problems are concerned. But I have never been able to see why anyone is entitled to a demonstrably false opinion. I once saw a perfectly unconcerned gentleman walking about the streets of London with a large biscuit-box stuck on his head in place of a hat. On the box was written in large letters, "The day of judgment is at hand." Well, more power to him! That is all I can say. He is entitled to that opinion. No one can deny the possibility that he may be right. But why is anybody entitled to a demonstrably false opinion as to how sex is determined?

A lot of the misunderstanding comes from people not taking account of the laws of chance. About the same number of boys are born as girls. Actually about 105 boys are born to 100 girls in most European countries. For the moment let us assume equality—(we shall discuss the reasons

for the departure from absolute equality later). Now suppose that sex is just a matter of chance, like tossing a coin. What do we mean by chance? We simply mean that a very large number of independent factors are influencing the result.

In tossing coins and catching them we have an example of pure chance. What does the result depend on? It depends on many independent factors. That is the point. It depends on which way the coin happens to be up to start with, whether it is level or at an angle, how hard I flick it round, exactly what part of it I flick, how far I throw it up in the air, whether there are any air currents in the room, how far it has fallen when I catch it, and whether it does or does not complete a turn when it reaches my hand, which itself depends on what part of my hand it touches first, and in what direction my hand is moving. If all those things were absolutely exactly the same every time, I should get the same result every time. But they *all* vary, and they vary independently of one another. That is what makes what we call chance. The more independent variables, the closer the approximation to pure chance.

The more times I toss, the closer will the approximation be likely to be to one head to one tail. If I were to toss a million times, I should get

something very close to 500,000 heads to 500,000 tails. But I may toss six times and get four heads to two tails. If so, what will happen if I toss six times again? What are the chances?

This is where many people go wrong. The chances are that I shall get three heads and three tails, *not* that I shall "make up" for what has happened, so to speak, by getting four tails and two heads. There is no making up for past events in pure chance. How could there be? Past tosses do not influence any of the many factors affecting the flight of the coin in the next toss.

I have got four heads to two tails. Suppose I am determined to toss a total of a million tosses altogether. I've got 999,994 tosses to come. Half of that is 499,997. The final figures which are now more likely than any others on pure chance are 499,999 tails and 500,001 heads. That is a very close approximation to equality, is it not? A good deal closer than 4 to 2! But the 4 to 2 at the beginning cannot influence what is coming later.

Suppose we toss a coin six times and write down the result, and then toss it six times again and write down the result, and spend the whole day doing that and nothing else. What should we find? We should find that more of our results were three heads and three tails than any other

combination. Next would come four heads to two tails, and two tails to four heads. There would be fewer still of the combination five heads to one tail, and one head to five tails. There would be least of all of the combinations six heads to no tails, and no heads to six tails. Try it, if you do not believe me. You must spend hours at it if you decide to try. Actually one can calculate mathematically how many of each combination one may expect.

So far we have dealt with pure chance. If you let the coin fall and roll on the floor till it drops, it is no longer pure chance. The head side is ever so slightly heavier, and tends to fall downwards rather more often than the tail side. It only makes a very small difference to the result, because in most cases the other factors influence the result much more. But just occasionally the coin runs levelly along the floor, and then it falls tails up, because the head side is slightly heavier. So in a very large number of throws we shall get rather more tails than heads. There is a slight bias in the tails direction.

Now at last we come to the point. The determination of sex depends on chance, with a bias towards the male sex. The questions are: What are all the factors which influence the chance? Can we direct them? And what causes the bias?

The sexual cells produced by men are called spermatozoa, or better, sperms. I spend most of my time studying sperms, because I am interested in birth control, and I want to invent ways of preventing them from fertilizing eggs. Sperms are microscopic little things looking rather like tadpoles. Of course one can only see them under the microscope. It is fascinating to watch hundreds or thousands of them all swimming aimlessly but rapidly in the field of the microscope, and still more fascinating to get just one in the field of view of the highest power lens and consider that in that microscopic speck there lies the whole inheritance from the father, the factors that would affect the development of every part of the offspring if it were allowed to fertilize an egg.

The eggs produced by women and nearly all mammals are minute, but not so small as the sperms. They contain the inheritance from the mother. The first sperm to reach the egg fuses with it, and the single cell formed by their fusion grows into the embryo. Directly the sperm has fused with the egg, changes take place in the egg, which make it impossible for the other sperms to fuse with it. All the other sperms die.

There are two sorts of sperms, male-producing and female-producing. That is not a theory: it is a fact. It is a fact which is totally ignored by the

ignorant people who pretend that they know how to control sex. The female-producing one has got a rod-shaped body in it called an X chromosome. You can see it in the developing sperm. The male-producing sperm has no X chromosome. If you are a woman, you have got an X chromosome derived from your father in every cell in your body. If you are a man, you have not got a single X chromosome derived from your father in your body. The X chromosome derived from the father makes the embryo grow in the female way. In its absence the embryo grows in the male way. It all depends on which sort of sperm happened to fertilize the egg from which you grew. And what decided that? Mainly chance.

About five million sperms compete for one egg. They all swim about at random until one reaches it. If you let a mixed flock of a hundred black sheep and a hundred white sheep loose in a field and left the gate open, the chances would be equal whether a white sheep or a black sheep would wander out first. But if white sheep happened on the average to be a little more active than black sheep, the chances would be slightly in favour of a white sheep getting out first. Make the assumption that the white sheep are on the average a little more active. Then, if you tried the experiment repeatedly, perhaps a black sheep

would get out first in 100 cases and a white sheep in 110 cases.

That seems to be analogous to what happens with sperms. We know for certain that male-producing sperms are produced in exactly the same number as female-producing sperms, yet more boys are conceived than girls. We do not yet know what the advantage is that male-producing sperms have.

You have to imagine the sperms all swimming about in a tube inside the body of the woman. They start at one end; the egg is up at the other end. They do not swim in any particular direction. Someone has shown that if you artificially put the sperms in at the wrong end, near the eggs, some of them find their way down to where they ought to have started; and they find their way down just as fast as they ordinarily find their way up. What factors decide which sperm shall be the one that gets to the egg first? It depends on where each sperm happens to be at the start; what direction it happens to be pointing in; how thick the fluid is through which it happens to have to swim at each part of its course; how many times it happens to bump into another sperm and into the wall of the tube; in what direction its course is deflected when it does so; what currents it meets in the fluid in which it swims; exactly

where the egg happens to be placed in the tube; and so on. There are so many independent factors that it is nearly a case of pure chance, but not quite, because male-producing ones do have some slight advantage, and do get to the egg first rather more often than the female-producing ones.

You must notice that the egg has not the least tendency to grow into one sex rather than the other. It is absolutely indifferent. That again is not a theory: it is a fact. It applies to man and all hairy animals, but funnily enough in birds things are the other way round. In birds every egg is determined as either a male-producer or a female-producer. In birds there are not two sorts of sperms: they are all the same. But in mankind and in all other mammals that have been studied, the egg has nothing to do with sex determination. The sperm decides it.

One odd guess that turns up from time to time is that one ovary produces male-producing eggs and the other one female-producing eggs. It is possible to say quite definitely that that is not so. You can completely remove one ovary, but the sex of the young ones produced is still mixed. The egg has nothing whatever to do with the matter in mammals.

Another guess is that the time of conception

makes a difference. That is an old midwives' tale. The whole question has been most carefully analysed, and it has been shown that in man the time of conception does not influence the sex ratio. In cattle the matter has been investigated on a huge scale, and it has been proved statistically that the time of service does not make the least difference to the proportion of the sexes.

How can these erroneous ideas have gained ground? That is not difficult to answer. Someone gets a "hunch" about the matter. Perhaps it is someone who has had several boys running. So she tells a lot of people how she thinks she has managed it, and they do likewise. Possibly a book is written about it. Some of the people who hear about it have a boy straight off, or two boys, or even three boys, and they think it is a case of cause and effect. They write and tell her, and she is confirmed in her opinion. The people who do not get what they want do not generally bother to write. You see, we expect on pure chance that a certain proportion of couples will have three boys running. You remember that we discussed all that when we were talking of tossing coins. One can calculate mathematically what proportion of families of three may be expected to consist of three boys, when the sex ratio at birth of the whole population is 105 boys to 100 girls.

The calculated proportion of all-boy families is what you would expect on the assumption of chance coupled with the slight bias in favour of the male-producing sperm that we have spoken of already.

If you happen to have six girls and no boys, you are very likely to think that there is something peculiar about you that makes you especially prone to have girls. It is not so. It is exactly analogous to getting six heads running when you toss coins. It happens with coins approximately as often as it happens with babies. If you have six girls, the chances are still about even what the sex of your next child will be. Of course, it may be a girl again. On pure chance we should expect a minute number of families of a dozen girls and no boys, if people had families as big as that nowadays. The unfortunate parents would be unable to imagine it as a case of chance, but it is chance all the same.

I can say quite definitely and certainly that there is at the moment no known method by which people can influence the sex of the children they conceive. I repeat that there are all sorts of superstitions that one can follow, and pure chance will give the desired result to a certain calculable proportion of the people who follow the superstition. The people who get the desired

effect will naturally make the mistake of imagining that it is a case of cause and effect.

Now suppose I said this: "Wear a brass ring round your little finger, and you will have only boys." If I said it sufficiently forcibly, probably lots of people would go off and do it. The next child would be a boy in about half the cases—rather more than half really, because of the bias in favour of the male-producing sperms. The ones who got boys would be very much pleased and would think me very clever. Roughly half of the lucky ones would have a boy again at the next birth, and roughly half of these would go ahead and have a third boy, unless they stopped having children. Well, these extra lucky ones would probably think me a perfect genius, but actually, of course, chance would have brought about the result, not the brass ring.

Shall we ever be able to control the sex of our children? Of course, I cannot say. I can only give my opinion, to which I am as much entitled as the gentleman with the unusual headgear. My opinion is that it is very probable that we shall. Someone has got to think out a way of separating male-producing from female-producing sperms: that is all. It sounds easy, and it is a thrilling problem that has attracted a lot of people, but no one has solved it yet.

If the female-producing sperms were larger than the male-producing (and there is some evidence they are), we might one day be able to make some sort of a filter to separate them. I have got a large glass tube in my laboratory reaching from the floor to the ceiling. I fill it with fluid and put sperms in at the top and wait. Their weight causes them gradually to sink to the bottom. I hoped that the female-producing sperms would sink more quickly than the others, but nothing came of it. Professor Huxley and I also tried racing them along horizontal tubes. We made them all swim towards the same direction by sending a weak electric current through the fluid in the tube. Sperms tend to swim towards the positive pole. We fondly imagined that they might conveniently sort themselves out into two groups. The group that got to the pole first would be the male-producing ones, we thought. But they did not sort themselves out at all. On the contrary, they remained in a single group. So that was no good.

You see, we know *how* sex is determined—by the sort of sperm that chances to reach the egg first. But we cannot *control* it yet. We cannot give one sort of sperm an advantage over the other. It is tantalizing to think of two and a half million male-producing sperms and two and a half million

female-producing sperms all swimming about at random, and the decision being left almost to chance. It is tantalizing because many people are desperately anxious to have a child of a certain sex, and there are millions of the right sort of sperms there, but we cannot control them. If only we could find out the nature of the advantage the male-producing sperms have, we might be able to give them an even greater advantage artificially. But that is one of the many unsolved problems of biology.

Only a few months before the publication of this book two workers in Moscow published a preliminary note on a method by which they claim to be able to separate the two sorts of sperms. They use an electric current, but in quite a different way from Professor Huxley and me. I remain sceptical until much larger figures are available. The results as they stand might be due to chance. Whether this will really be found to be a dependable way of separating the two sorts of sperms or not, I do not know, but I do think it very probable that one day we shall be able to separate them. Then what?

People have often said to me that if we could decide the sex of our children, nearly everyone would have boys, and the race would almost die out. Certainly there would be a chance of every-

thing being topsy-turvy at first, and for a year or two we might get some extraordinary sex ratios. But I don't think it would go on. When Mrs. Jones and Mrs. Smith and Mrs. Williams and Mrs. Robinson had all had a succession of boys, just think what excitement there would be when Mrs. Johnson went and produced a girl! Girls would have quite a rarity value. Also I have found that people in general do not really want to have boys only. Most people prefer a mixed family. I consider myself lucky because I have got a girl and a boy. You must not think that I arranged it. It was chance, as in the case of every human family that has ever been conceived.

The people who would benefit chiefly from the power to control the determination of sex would be people who by chance have had several children of one sex and none of the other. The nation as a whole might benefit also, because it is generally best to have about the same number of men as women in any non-polygamous country. Although more boys are born than girls, boys are more delicate on the average, and men tend to be killed in accidents more than women and also to die younger without accidents, so we always have more women than men, and many women can never marry. At every age above 19 there are more females than males. In 1921 there were 118

women aged 20–24 to every 100 men, and 120 women aged 25–29 to 100 men of the same age. Here are the figures for each of the succeeding five-year groups: 119, 116, 113, 107, 107, 109, 113, 119. The next group is the age-group 70–74. Look how the preponderance of women increases rapidly at these ages: 134, 148, 168, and finally at ages of 85 and more, 205 women to every 100 men.[1]

The State could easily keep the sexes about equal if it wanted to, if we could control the sex ratio. It would not be difficult to think out some way of encouraging people to have children of the required sex. Control of things that previously were not controllable is one of the applications of science. Control of the sex ratio would be just one example of it. Pure science aims simply at a description of the universe, but one of the effects of science is to give us control over nature. We must think quickly, so as always to be prepared to use our control in the way that gives the greatest benefit to the greatest number.[2]

[1] A. M. Carr-Saunders and D. Caradog Jones, *The Social Structure of England and Wales*, Oxford, 1927.

[2] For a more detailed account of the determination of sex, see J. R. Baker, *Sex in Man and Animals*, Routledge, 1926. See also F. Ökland, *Is it a Boy?*, Allen and Unwin, 1932.

CHAPTER IV

The Quality and Quantity of Mankind

THERE is no evidence that our inborn nature, bodily or mental, has evolved since the beginning of civilization. There is no reason why it should have evolved. Evolution is supposed to happen in wild life because the ones that chance to be the fittest to survive are the ones that do survive. We know that vastly more young are born in every species than grow up and reproduce their kind. On the average it will be the ones that happen to be well equipped for the battle of life that will survive. The young ones may inherit the advantages that ensured their parents' survival.

In social animals this survival of the fittest does not act so much on the individual as on the herd. When a herd is attacked, the strong and brave members of it are more likely to be killed than the weaklings. An individual which would not be capable of finding its own food for itself might easily survive in herds. It would rely on the leaders to bring it to good pastures. Survival of the fittest would apply rather to the fittest herd than to the fittest individual. Weaklings could be

tolerated until they seriously undermined the efficiency of the herd as a whole: then the herd would tend to get wiped out as a whole, from attacks of enemies or inability to find food.

I think that if we remember this, we may find a clue to the meaning of polygamy. In many social animals the males have several wives. The sexes are about equal in numbers, so of course many males get no wives. That seems a bad arrangement, but is it really bad? The males fight together for the possession of the females. You see that in many sorts of social animals—deer, for instance, or seals. It is only the brave and strong ones that can mate and have young. The weaklings in the herd are tolerated, but in the polygamous species they do not have any young, and so they do not transmit their weakness to offspring. I think that that must be partly why polygamy is much commoner in animals that live in herds than in animals that do not. But there are exceptions to everything in biology, and the wild-duck is strictly monogamous when living a wild life, although it is a social animal, and the lion is sometimes polygamous, although it does not live in herds. We must take full account of these exceptions, but nevertheless we can see that social animals would gain a certain advantage from polygamy. It would help them to avoid the one

great disadvantage of social life to the species, the preservation of the unfit.

What is the primitive condition of mankind as regards marriage? Was he polygamous, or did he stick to one wife in prehistoric times, when he was just emerging from his ape-like ancestry? I do not know and nobody else knows, but there are many anthropologists who think there was what is called "group marriage", the mating of several people of one sex with several of the other. There is a good deal of evidence for it, mostly derived from a study of primitive people living in various parts of the world to-day. It is largely based on their having no special word for "mother". They call their mothers by the same name as they call all the other women whom their fathers would have been allowed to marry. And it is the same with their fathers: they have no special word for them. The evidence is most ingenious, but I doubt whether it is conclusive. I think I am right in saying that no animal practises group-marriage. Now polygamy is very widespread in social animals, and man is a social animal, and many races of man are to this day polygamous. It may be the natural condition.

When reason replaces custom, the habits of mankind are changed; and in the highest civilizations monogamy has replaced polygamy, probably

because of the trouble that is caused if there are a lot of unmarried men about. Civilized men do not want to be fighting all the time, and the natural tendency of polygamy is to make men want to fight for wives, and the ones who do not get any will be discontented. Also polygamy puts women into an undeserved position of inferiority, so that there are good reasons for encouraging monogamy. But there is one evil result. Since all males may marry and have children, the one great disadvantage of social life is encouraged: the weakling, who is preserved by the herd as a whole, may reproduce and transmit his undesirable qualities to his offspring; and the herd will take care of those too.

It is instinctive in social animals to look after and protect feeble members of the herd. It is primarily an instinct to protect the young and the females, I suppose, but anyhow there must be this general altruistic defensive instinct in any herd, and it may extend to any member of the herd who is in difficulties. I used to have a cocker spaniel who had an extraordinarily strong instinct to protect my wife from strangers, and often he was very much worried if I played at all roughly with her. He thought she was being attacked, and he was on the defensive for her.

Among ourselves we call this instinctive altruism "humanitarianism". It is quite necessary for our life as social animals. People differ extraordinarily in the amount of sex instinct and self-preservation instinct that they have got, and it is the same with the humanitarian instinct. Some people suffer nearly as much from seeing or thinking of other people suffering as from suffering themselves. Other people seem scarcely affected by other people's sufferings. Obviously some sort of mean between the two is desirable. The anti-humanitarian—the person who does not feel for others at all—cannot help it any more than a man who is devoid of sex instinct: but he is quite unsuited to social life. The person at the other extreme lacks the amount of hardness that is often necessary for decisive, courageous action, and also he is not necessarily the person who actually does most to prevent suffering.

This is the whole burden of what I want to say: normal people instinctively want to help the weak members of the community, but the result of this is that the weak members of the community survive and transmit their weakness to their children. So we are in a dilemma: what shall we do?

First of all, let us find out who are the weak. There are quite a lot of people who think that if

only all the people who call themselves "upper-class"—it really means just the rich people—were to have lots and lots of children, and if only all the poor people were to have very few, we should be all right as a nation. Now that presupposes that the rich people are rich because they possess some inborn superiority over poor people. Well, do they? That is the first problem.

So far as physical characters are concerned, there is a big average difference between rich and poor people. Rich people are on the average considerably taller (though, of course, there are plenty of tall poor people and short rich people). Someone measured the schoolboys aged 14 in Liverpool.[1] The average measurement at a secondary school was 5 feet 2 inches; at a council school in a poor district it was only 4 feet 7 inches. Probably these physical differences between the classes are caused largely by differences in the food of the growing child.

What about intelligence? That is a much harder problem. Is there any difference between the various classes in their inborn intelligence? How shall we find out? Obviously it would not be any good to test people in Latin to find out. The children of the professional classes usually learn Latin, and the children of labourers usually

[1] A. M. Carr-Saunders, *Eugenics*, Williams and Norgate, 1926.

do not, so we could not find out anything about intelligence in that way. Obviously our tests must not deal with subjects which are taught to one class and not to another. So far as possible they must not give an advantage to any special class. For instance, it would not be fair to ask, "How can one live on 15s. 4d. a week?" because a rich person would not have the slightest idea, however intelligent he might be.

The best tests are not perfect, but they do try so far as possible to avoid giving any benefit to people with special environments. There are tests for every age from 3 to 16. It has been found experimentally how hard each test must be for the average person of each age to be able to pass it, but not to be able to pass the test for the next higher age. The tests do not generally go farther than 16, because our intelligence does not seem to increase after 16. Of course, we go on getting more and more experience, but we do not get any more intelligent. I must admit, though, that some experience of life is quite essential to doing most of the tests.

Here are a few examples from Terman's tests.[1] Here is one for age 16. "Define the difference between character and reputation." I hope I

[1] R. Pintner, *Intelligence Testing Methods and Results*, University of London Press, 1924.

agree with Mr. Terman on that. Here's one for age 12. "What similarities are there between wool, cotton and leather?" Here is one for age 10. "Why should we judge a person more by his actions than his words?" One feels glad that one is not 10! Now age 3. "Repeat six or seven syllables, such as: 'I have a little dog'." Each test consists of a number of most varied questions.

Idiots are people who never arrive at the mental age of 3. Imbeciles are grown-up people who pass the test for the mental age of 3 with flying colours, but fail at the test for 8. The Americans have a special word for people who can do tests for children of 8, but cannot do tests for children of 11. They call them "morons". The word "feeble-minded" is a general one for people whose intelligence fails to develop, so that their mental age is that of a child.

A couple of investigators gave tests to 548 children in American schools. They found the average marks obtained by the whole group. Then they grouped the children according to the class their parents belonged to—professional, executive, artisan or labourer. They found that 85 per cent. of the children of the professional classes got more than the average marks; 68 per cent. of the children of the executive class got more than the average marks; only 41 per cent. of the artisans'

children and 39 per cent. of the labourers' children got more than the average. A good many other people have made similar tests elsewhere. Someone found that 60 per cent. of the professional class children got more than average marks. The figure for labourers' children was 47 per cent.

The general conclusion to be reached from a study of the results of these intelligence tests is this. High and low intelligences are distributed among every class of the community, but there is a tendency for people of high intelligence to be rather more abundant in the professional class than in the labouring class. Of course, the feeble-minded will usually tend to find their way into the poorest classes, and thus bring down the average of the intelligence of the poorest classes, however intelligent the people may be whose poorness is due to accident of birth.

The general conclusion which I reach is that it does not matter very much, in the present circumstances, from what class of the community the next generation is chiefly derived, but the average innate intelligence would probably be somewhat higher if it were derived largely from the professional classes and somewhat lower if derived largely from the labourer class. But in *any* class we could find an abundance of people

of the highest inborn intelligence who would be the most suitable parents of the next generation. Any class could provide such people, but there would be a somewhat higher proportion of them in the professional class than elsewhere.

At the present time the professional classes have, on the average, considerably fewer children than the poorest people, and this is probably not in the best interests of the country. If the professional classes consisted simply of the people of the highest inborn intelligence, then it would be a tragedy for the nation for them to reproduce most slowly of all: but it is not so. It could only become so if everyone were given an equal chance of becoming a member of the professional class.

It *is* possible for the children of very poor parents to get the best possible education, if they are lucky and intelligent and precocious, but it is difficult. Think how easy it is for the children of rich parents! They can get a University education without any effort unless they are fools, and then they can pass on to a profession. Think what thousands of others are equally well equipped mentally, but have no possible chance of making the fullest use of their brains! What chance has the child of a poor man to become a doctor or a lawyer?

So long as we make it very difficult to pass from

one class to another, it does not matter very much which class reproduces most rapidly. Now we must revert to a matter we have discussed before, the herd instinct. The normal herd instinct in animals acts for the benefit of the herd as a whole, but among men an extraordinary perversion of the herd instinct has arisen. People's sympathies tend to be for those other people who have about as much money as they have themselves, and they transfer their herd instinct just to that group or class, and tend to be suspicious of other classes. People often pretend to a great patriotism, but (except perhaps in times of national emergency) the class feeling is a much more real thing than the unperverted instinct, which is a feeling of sympathy with other people of one's own race as a whole. It is this strong class feeling, which I regard as a perversion of the herd instinct, which prevents the best brains from getting surely to the top.

If we really wanted above everything else that our race should flourish, we should give everyone a really equal chance to succeed, and should see to it that the people who had the highest inborn intelligence and energy were the ones who were actually doing the work requiring the most brains. Having found those people, we should encourage them to have as many children as would be con-

sistent with the mothers' and children's health and welfare. The people who were inferior we would encourage to have few children. That would be true patriotism, something very different from the flag-waving and anti-foreign propaganda which now flourish under that name.

I have mentioned that people of the professional classes have on the average considerably fewer children than poorer people. On the whole there is a tendency in England and many countries for people to have fewer children the richer they are. Why is this? It was not so a century ago. There seems to be little doubt that it is due to their using birth-control methods. It seems probable that the majority of couples among the rich and in the professional classes who are not sterile use some form of birth control. Poor people have less money to buy books about the subject, and in various ways their poverty disqualifies them from making use of the information.

To understand problems of birth control it is essential to remember that our inborn instincts and natural fecundity are unlikely to have changed since the times of our ape-man ancestor. Evolution probably only occurs as a result of the survival of the fit, not as a result of the survival of the offspring of those who have less sex instinct and less natural fecundity than their neighbours.

We are therefore still adapted physiologically to the production of vastly more children than is now necessary. We have lowered our death-rate since those ancient times, and it is still falling. If we were to keep our birth-rate at the old figure, we should become seriously overpopulated. There is some likelihood that Great Britain is already overpopulated: I mean that we should have a higher average standard of living if we had fewer people. Economists generally fail to take sufficient interest in population problems. They would like to be clever enough to arrange a policy that would result in everyone having sufficient of the good things of life, whatever the population. As a biologist, I look at the matter differently. I should like to see our birth-rate controlled so as to give the highest possible average standard of living.

Most people who use birth-control methods probably do so without any particular thought of the State as a whole. They are concerned with the health and happiness of the mothers and children concerned. A mother's life may be rendered almost intolerable by pregnancies following one another in quick succession, and there is evidence that children tend to be healthier when they are not born in quick succession. In poor families the birth of each child reduces the standard of living of the others.

It is questionable whether very poor people, who cannot support large families, should be encouraged to have them. Every living man, woman and child has a right to work or full maintenance in any civilized state, and in the same way it may be argued that people have a duty to the State not to produce children which the State has to support, if the State is already overpopulated.

Perhaps in the distant future we shall have a Ministry of Population. Its job will be to estimate the best population for the conditions, and to devise means of securing a decrease or increase of the birth-rate as required. If the politicians make the conditions different, the Ministry of Population will have to adjust the population.

At the present moment there is no Ministry of Population, but the Ministry of Health allows Local Authorities to run birth-control clinics. Forty-one local authorities either have already established special clinics, or give birth-control information at gynaecological clinics, or refer cases to voluntary clinics or to private doctors, or authorize their medical officers to give advice. Nine others have decided to give birth-control advice, but have not started yet. Three others have lent premises to the National Birth Control

Association for use as voluntary clinics. These figures come from the secretary of the Association. Voluntary clinics are run by this Association and also by the Constructive Birth Control Association and by the Society for the Provision of Birth Control Clinics.

It is important to realize that in this country birth control is perfectly legal. It is legal to make, advertise, sell and use contraceptives.

So far there has been little laboratory research on the subject, but things are moving forward. The Birth Control Investigation Committee is the body that organizes the laboratory research, and I am one of the workers under it. At present the birth-control methods are not absolutely reliable. No method can be countenanced that is harmful. The possibility of harmful effects is being investigated under the auspices of the Committee. The harmfulness of contraceptives has been made much of by people who could not tell a damaged tissue from a normal one, if provided with a perfectly good microscope and a perfectly good microscopical section of the tissue. Certain methods have been found to be quite harmless.

We have seen that it probably does not matter tremendously what class of people reproduces most, so long as we go on making it difficult for people to rise from one class to another. But,

apart from classes, is there any *sort* of person who ought not to reproduce?

To that I answer, "There certainly is." The congenitally feeble-minded person should not have children. If a normal person becomes feeble-minded as a result of a blow on the head, it does not matter if he or she reproduces, because the children will not inherit the defect; but if a person inherits feeble-mindedness, he or she will transmit it to descendants. We must distinguish between inherited and non-inherited feeble-mindedness. Goddard found that 54 per cent. of the feeble-minded people he studied had feeble-minded relations. Whole families of people have been studied in detail by Lidbetter, showing this feeble-mindedness in generation after generation. There are notorious families in America in which feeble-mindedness has been passed on unceasingly. People sometimes argue that one cannot define the symptoms of inherited feeble-mindedness in such a way as to distinguish it from accidental feeble-mindedness, and therefore there is no such thing as inherited feeble-mindedness. That seems to me a poor argument. It fails to take account of something that is common knowledge to biologists—that a character may be affected in the same way by inheritance as by environment.

The inheritance of congenital feeble-mindedness is not absolutely understood, but one form of it behaves like what is called a Mendelian recessive. That means that a person can suffer from it although neither of his parents did, and he can transmit it to his descendants, though not necessarily to his sons or daughters. Also it means that it is particularly likely to appear among the children of cousin marriages. If two feeble-minded people marry, all the children are likely to be feeble-minded. Sometimes all the children are not feeble-minded, and then people with a little knowledge of biology think that we really know nothing about the inheritance of it, because it does not fit in with simple Mendelian schemes. A little learning is a dangerous thing. It is not difficult to account for such cases, if one has an adequate knowledge of the laws of inheritance.

There is a good deal of evidence that the feeble-minded are increasing in numbers in this country. They are careless of the consequences of their actions, and they reproduce rapidly. They appear to be a real danger to the State. They are the weak members of the herd. So now we are really back at what we were talking about at the beginning. The weak members of the herd in a polygamous species are protected and led to good pastures, but the weak males do not reproduce.

Polygamy sees to that. We are not polygamous, so we must take other steps to prevent the reproduction of the congenitally unfit. Men may be sterilized quite simply. This is a small and simple operation. A general anaesthetic is not required. A local one suffices. It is a fact that most people have not the slightest idea what the sterilizing operation is. They imagine it to be the same as castration, the operation carried out on male farm animals which are not required for breeding. It has nothing to do with that operation. That operation removes the sex instinct and changes the bodily growth of young animals. The sterilizing operation has no such effect. If a man were to be sterilized without being told what was being done to him, he would continue with his ordinary married life without the slightest idea that anything had happened to him. He would be surprised to find that he had no children.

It should be made legal for any congenitally feeble-minded man to be sterilized if he agrees to it himself, if his wife agrees to it, and if the Board of Control gives consent. It is not proposed that anyone should be sterilized against his will, if he is sufficiently intelligent to express his will.

For women the sterilizing operation is a major abdominal operation, and I am doubtful whether we should be justified in encouraging anyone to

undergo that except for reasons of personal health. What is wanted is some more research into simple ways of sterilizing women. The trouble with feeble-minded people is that they are too careless to use birth-control methods.

Some people think that those who ask for the legalization of sterilization are anti-humanitarians, who want to attack the weakest members of the community. It is not so. The legalization of sterilization would be most humane, because it would prevent the birth of people who cannot hope to live really happy and useful lives.

The newspapers are filled with politics, politics, politics: chiefly flag-waving and class war! Just occasionally a little paragraph is hidden away somewhere dealing with the really live issues that we have discussed in this chapter. We could cut out class war. We could make sure that talent always rose to the top. We could encourage the reproduction of the best stocks and prevent the reproduction of the unfit. We could make sure that the population of the country was adapted to its needs, and that mothers could always space births to the greatest advantage of their children and themselves. Any nation which decided on that course of action would rise supreme.

Shall we continue just to muddle along anyhow? Probably we shall.

CHAPTER V

War, Disease and Death

"War is a biological necessity." We have all heard that. At least, I confess I have not ever heard a biologist say it, but it is pretty generally accepted by lots of people, and it sounds learned. Let us examine it. What is at the back of people's minds?

I think it all comes from the struggle for existence and the survival of the fittest. We know, of course, that even the slowest breeding animals produce far more young than can ever grow up and themselves reproduce. There must be a continual struggle to obtain a sufficiency of food and to avoid carnivorous enemies. Only the larger carnivores are free from any obvious attack. There is no animal that attacks them offensively, though, of course, the larger vegetarian animals will use all their strength in defending themselves against them. I say they are free from obvious attack, because of course they are not free from the attacks of parasites.

Almost every animal one sees has its parasites. A favourite question in examinations for zoology students is the removal of the parasites from a

frog. One need not bother to ask oneself whether the frogs one supplies to the candidates have got any parasites. They are all stuffed with them, in lungs, intestine and bladder. I have never come across an earthworm in which I could not find parasites. Wild mice are usually parasitized by fleas, and ticks are found on the skin of all sorts of beasts. Bats are often crawling with curious parasites. Birds have special insects living beneath their feathers.

Obviously or not obviously, a great struggle for existence goes on in nature. Carnivorous and parasitic animals are utterly ruthless as to the suffering they cause (although, as we shall see later, it is generally not to the advantage of parasites actually to kill).

The struggle goes on everywhere, but is it war? What is war? I think it is impossible to speak of war except in a social kind of animal. It is a fight between one herd and another herd of the same kind or a closely allied kind.

Now let us review the whole animal kingdom and describe all the wars the different social animals have. Let us go right through all the different social mammals first of all, the ones I mentioned in the second chapter: the marmots, beavers, vizcachas, horses, deer, oxen, antelopes, sheep, goats, porpoises, dogs and wolves, seals,

fruit-bats and social monkeys. Let us describe the different sort of war each kind goes in for—how they fight herd against herd amongst the same kind—the weapons and tactics they use, the biological significance of the whole thing. Shall we go right through that? All right.

It is a simple task, I am glad to say. War, as I have defined it, is simply non-existent in the animal kingdom, except possibly in the slave-making ants. Elsewhere, throughout the whole animal kingdom,[1] there is nothing remotely resembling war: and even in ants it is not really war according to our definition, because there are not fights between different nests of the same species or of closely allied species. So far is war from being a biological necessity that it is practically biologically unknown except among human beings.

We must regard all races of man as being of the same kind or species, because a person of any race can marry one of any other race and have children who are themselves perfectly fertile, so far as is known. That is the only criterion of a single kind or species that we have that is of any value, though I admit it is not perfect.

In social animals, each herd has its own

[1] One hive of bees sometimes attacks another.

territory, and it never invades the territory of other herds. The territory instinct is extraordinarily strongly implanted in animals.

Take the antelopes, just as a random example. The feeding-ground of each herd is sharply marked off. A herd never invades another herd's territory. Occasionally a few individuals may trespass across the boundary, but they are at once driven away, and they give the appearance of knowing that they are in the wrong, for they will not fight to maintain their position, as they would unhesitatingly if they were on their own ground. The dog is an example familiar to everyone. For the domestic dog his master's house and garden, if he has got one, represent the territory of the pack of his ancestors. A dog that never fights in the street (that is neutral territory) will fight ferociously if another dog happens to stroll in through the open gate. The dog that strolls in knows that he is in the wrong, and generally escapes as soon as possible, even if he is a bigger dog and ordinarily more ferocious.

There is one antelope in particular that gives a splendid example of respect for the territory of others.[1] The springbuck of Bushmanland is a little yellow-coloured antelope similar to a gazelle, but differing in having a white stripe along the

[1] See Heape, quoted in footnote to p. 45.

middle of the back over the haunches. Males are about thirty inches high at the shoulder. The springbuck lives in almost desert country. Like the lemming, it has periods of increased population during which starvation is threatened. At these periods, like the lemming, it emigrates. There are fertile areas all round except to the west, but they are occupied by another race of springbuck and by other kinds of antelopes. The springbuck of Bushmanland, although starving, does not go north or east or south. He could find plenty to eat there, but the ingrained instinct not to invade occupied territory is too much for him. He goes west in every sense of the term. He loses all his natural timidity and marches in enormous herds over country in which he cannot live towards the sea. If he comes to a village, he sweeps through it as though no longer afraid of man. The advancing army may be several miles wide and over forty miles long. It streams onwards, sometimes crossing rivers. At last, after a march of about two hundred miles, it reaches the sea. All plunge in and are drowned. None return. To the springbuck this mad useless emigration is preferable to an invasion of occupied territory.

We reach this conclusion: herds of social animals have their own territories, and never start aggressive wars against other social animals of

the same or closely allied species. If there is any individual trespassing, there is a strong defensive instinct which causes the trespasser to be ejected.

I speak purely from the biological and not in the least from the military point of view when I say that to resist trespassing on one's own territory is probably instinctive and natural, while there is no biological basis for aggressive warfare. Militarists sometimes think it necessary to carry out operations outside the home country in order to defend the home country, but in so doing they cannot rely on instinctive support from the people of their country; but when their country is actually invaded, then instinct probably prompts resistance.

When we consider man's nearest allies among animals, we find that the male is commonly larger than the female, and the significance of this greater size is that he has an instinct to protect his wife and family. It would be useless to be bigger and stronger if there were no such instinct. The difference in size is not great in the orang-utan and chimpanzee, but it is very great in the gorilla. There is of course a considerable average difference in size between the sexes in mankind, and one cannot fail to appreciate its significance. Men are almost certainly more innately ferocious

than women. Women seldom really like having a good row with one another. However much they may like making what are called "catty" remarks in the absence of the person they dislike, they very seldom show their dislike openly to the person concerned. Now that is just what many men do like doing. I have often thought what a lucky thing it is that the differences between the sexes in mankind are so small compared with the differences one finds in many kinds of animals. Think what life would be like if men were as innately ferocious as bulls or male mandrills! We are spared that, but it is nonsense to pretend that the two sexes are exactly equivalent as regards the instinct to fight when annoyed.

I conclude that most men would find themselves almost driven by instinct to fight if their own territory were invaded by hostile foreigners, however much opposed to war their reason might tell them to be. Even the Oxford Union would be less pacifist in the presence of an invading army.

I have enormous sympathy with pacifists, but I think they tend to overlook men's innate instinct to protect their own territory. I am not saying whether it is a good instinct or a bad instinct: I am only saying that the instinct probably exists. When people try to overcome instincts, they

generally have no success with the great majority of normal people. The medieval Church tried to overcome the sex instinct, and a few people still leave the world for monasteries and nunneries: but the race continues to exist. I often find that pacifists regard non-pacifists with something like horror. They would get a much more sympathetic hearing if they were more sympathetic themselves, and realized that the man who is prepared to fight for his own territory is probably only obeying his instincts in the same way as he does when he marries and has a family or refrains from walking about in woods alone at night.

As for the aggressive militarist—the man who wants his countrymen to fight abroad to increase his territory—he cannot pretend that it is likely that there is any innate instinct to do that, as no animal does it, and we have no knowledge of any human instincts which do not occur also in animals.

That is enough about war. We have still two equally cheerful subjects ahead of us, disease and death.

Obviously I am not going to look at disease in the ordinary way. You would have to get a medical man to do that. I want to look at disease from a biological point of view. We have seen that carnivores and parasites are absolutely ruth-

less: it is all part of the never-ending struggle for existence. It does not matter to a parasite whether it makes the animal it lives on ill or not: its own survival is all that matters to it. Parasitic life has its obvious advantages: the parasite has not got to go searching for food. A flea can eat whenever it wants to. Nevertheless parasites are up against one big difficulty. It does not matter to them how much illness or pain they cause: but if they *kill* the animal they live on, then there is trouble. It usually means the death of them also.

Suppose a man has got malaria. That means he has got some little single-celled animals inside his red blood-corpuscles. So long as he goes on living, these malaria germs are all right. Every now and then he may be bitten by a malaria mosquito. The mosquito sucks up some of the germs and infects somebody else with them later on. That is all right for the malaria germs. But suppose the malaria germs go and kill the man. What advantage do they get out of that? None at all. On the contrary, the result is that they all die themselves. That is why the vast majority of parasites do not kill the animals they live on: it would be death to themselves. In the course of evolution they will become better and better adapted to the animals they live on. They will avoid the most vital organs, and will not produce

any deadly waste products. It is generally only the maladjusted parasites that kill, the ones that have not yet become adapted to their hosts nor their hosts to them. Also death of both often occurs if a parasite happens to get into the wrong animal, because then neither is adapted to the other. In continental countries men are to some extent adapted to the influenza germ, and influenza is not usually a very serious illness; but influenza is not a disease that occurs naturally in the western Pacific Islands, and the Melanesians are not adapted to it. The result is that if someone goes to those islands with influenza, the natives catch it and die off like flies.

Sometimes it does not matter to a parasite if it kills its host in the end. There are animals called ichneumon flies that lay their eggs in or on the caterpillars of other insects. The eggs develop into caterpillars which live inside the other caterpillars and gradually eat them up. If they started eating the brain, their hosts would die, and they would die too as a result: so at first they only eat the less essential organs. Later on they do kill their hosts, but only when they are just ready to come out and change to the chrysalis stage. They do not eat in the chrysalis stage, so it does not matter that they have killed their hosts.

There are just a few parasites that must kill

their hosts for their own good.[1] These are microscopic animals that live in the muscles of fishes. They cannot get out through any of the apertures of the body, so they have only one way of getting from one fish to another, and that is by the death and disintegration of the one they are living in. They multiply enormously in the muscles, and the muscles are used up and the fish dies. Other fishes accidentally infect themselves when they come across disintegrated bits of the dead fish. Nothing of this sort happens with land animals. With them, death of the host usually means the death of all internal parasites.

Thus it is not to the advantage of parasites to kill their hosts in the vast majority of cases. Nevertheless they certainly do often kill them. A tremendous amount of human death does occur from diseases caused by parasites. What would happen if we prevented all disease caused by germs or parasties of every sort?

Suppose a very rich man in good health thought that the most worth-while thing in the world would be just to go on living. Well, he could get a special room made for himself, and have it sterilized so that it did not contain any germs. He could go through a course of treatment to

[1] E. A. Minchin, *An Introduction to the Study of the Protozoa,* Arnold, 1912.

make sure he was free from all parasitic disease. Then one day he could have the surface of his body sterilized and with all the necessary precautions he could enter his room. Only sterilized air would be allowed to enter the room. Nearly all his food would have to be cooked to prevent germs from getting in with it. Special precautions would have to be taken in introducing those vitamins that are destroyed by cooking. Double doors would have to be used for introducing anything into his room or removing anything from it; and when things were being introduced, it would be necessary to leave them for a bit between the double doors and meantime have the air between the doors sterilized. The man could only open his inner door when that had happened.

With some such arrangement as this it would be possible for a man to make sure that he did not die of infectious disease. Would he live for ever, or is there such a thing as natural death?

In the young embryo, the cells that compose the body are not specialized for their various jobs. As the body grows up, they become specialized in various ways, some as nerve cells in the brain, others as digestive cells in the intestine, and so on. As they become specialized, they lose their power of living. Irreversible changes tend to occur in them, which finally result in their death.

Now this is the interesting thing: if you can change them back to their embryonic, unspecialized condition, you can give them a new lease of life. The length of time they have existed does not matter, if you can do that.

With flat-worms you *can* do that. If you put some meat in an open bottle and leave the bottle in a pond for a few days, you will probable find some flat-worms in it. An ordinary sort is about an inch long when fully grown. In time it would die in the ordinary course of events, but if you put it in perfectly clean water and do not feed it, a very remarkable thing happens.[1] It uses up its own substance as food, and gets gradually smaller and smaller, until it is only a quarter of an inch long, and narrow in proportion. This is the interesting thing: the cells have become unspecialized, almost embryonic, the cells of a young animal. Of course, you could starve it to death: but if you now start feeding it, it grows and develops like a normal young flat-worm. You have given it a new lease of life. When it is full-grown, you can do the same thing again, and so on repeatedly.

There is another way in which you can make cells become embryonic and so give them a new

[1] Child, *Senescence and Rejuvenescence*, University of Chicago Press, 1915.

lease of life. If you cut the hinder four-fifths off a flat-worm, and keep just the head end, some of the cells of the head end become embryonic and start dividing and give rise to the whole of the missing part. When that has happened, you can do the same thing all over again, and again and again. It has been done thirteen times, and then the animals were only killed accidentally. One can certainly rejuvenate the cells of flat-worms.

The trouble with the higher animals is that you cannot rejuvenate the nerve cells, the cells of the brain and spinal cord. When a nerve cell has once been fully formed in one of the higher animals, it never divides again. If it were to divide, there would be a chance, because cells commonly get a bit embryonic when they divide. In other tissues occasional cell divisions occur; but the cells in my brain are the self-same ones that will be there when I am an old man, except for those that have died off before I am old, and that is a thing that has probably started already, as I am thirty-two. So far, no one has thought of any way of rejuvenating old brain cells, or preventing them from gradually dying off. One can rejuvenate the rest of the body to some extent sometimes by giving gland extracts, or by stimulating certain ductless glands to do their work; but the brain goes on growing old. It is conceiv-

able that one day someone might find a way of making nerve cells grow embryonic again.

Natural death in man is probably death from old age of the nerve cells. Other parts of the body cannot go on long without the brain, though the skin does not die instantaneously at the moment of what we call death, and hair may continue growing for a bit after heart and lungs have ceased to act.

Is natural death in the animal kingdom always the result of the death of nerve cells from old age? Certainly not. The Mayflies provide an obvious example.

The nymphs of Mayflies live for one to three years under water in ponds and streams. One day, often in May, they come out of the water, cast their skin twice in rapid succession, and emerge as finished Mayflies. The finished Mayfly has only rudimentary jaws, inherited from an ancestor which used to eat: but they are useless. It has a mouth, but it is not used for eating. It has a digestive tube, but it is not used for digesting. It fills its stomach with air and can take in more or let part of it out. This process seems to have something to do in an obscure way with balancing, but it is difficult to see exactly how it works. Anyhow, it does not eat. It mates, lays its eggs if it is a female, and dies of simple

starvation of all its tissues. That is natural death for a Mayfly. Sometimes its natural life in the adult form is less than a day.

Every law in biology has its exceptions, and the salmon seems to provide exceptions at every stage in its career, so I do not pretend to be able to lay down the law. I shall try to present the life-history of an average salmon very shortly, to illustrate this talk about death. There are differences of possible behaviour at almost every stage.[1]

Suppose some eggs were laid in gravel in shallow water in a river last November (1932). They will have hatched into tiny fishes, what are called "fry" by now (spring), and by autumn they will be two or three inches long and they will have dark bands and spots on them. These "parr" will live this winter and next winter in the river, but in the spring of 1934 they will lose their markings and become silvery, and their tail fins will become more pointed and they will migrate as "smolts" to the sea during the early summer. They will then live an entirely marine life for a bit. The following summer (1935) they may return to the river as "grilse", but others will wait until the summer of 1936,

[1] P. D. Malloch, *Life-History and Habits of the Salmon . . .*" Black, 1910.

or till the winter; but perhaps still more of them will remain in the sea till the spring of 1937. Then they will come up from the sea to the rivers to breed, and when they come to a waterfall they will jump it. They can jump up to as much as ten feet at a time. Now the whole point is that from the moment they leave the sea they cease to feed. Meanwhile their reproductive organs are growing at the expense of their muscles. In November or later the females lay their eggs and the males pour the milt over it. The spent fish are called "kelts", and thousands of them may float helplessly downstream with the current and die. It is usually said that they have died of starvation, because they have not fed in the river; but I think the cause of death must really be largely the sudden change in bodily functions when the spawn and milt are discharged. The body is already enfeebled by lack of nourishment, and now this shock to its system usually kills it, though some return to the sea and eventually breed again in the river.

Thus, different animals have different natural deaths. To keep a salmon alive unnaturally long, we might try to prevent it from allowing its reproductive organs to grow. To keep a Mayfly alive, we should have to devise means of nourishing it. To prolong human life, we should have

to find out how to make the nerve cells embryonic once more. We have seen, from our study of the flat-worm, that that is not theoretically impossible.

Lastly, the llama. I should say the huanaco, because I mean the wild beast, not the tame variety. He is a sort of humpless camel, and he lives in the desolate stony plains of Patagonia in South America. He lives his life in herds, far from any cover or concealment. When he is going to die, a strange instinct comes over him. He makes for a special spot at the southern extremity of Patagonia. There, on the banks of a river, are thickets of small twisted trees. This lover of open plains squeezes himself in under the branches and deposits his bones with those of generations of his ancestors. Hudson[1] thinks it is an instinct inherited from the time when his ancestors were forest animals which always retreated to cover when in danger or difficulty. If so, it is a retained useless instinct like our own instinct of clinging on tightly with our hands and even with our toes when we are frightened, which is quite useless to us now that we no longer live in trees.

[1] See footnote to p. 39.

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CHAPTER VI

Biology and Statesmanship

I LIKE controversy, and I confess I had rather hoped that Dr. Baker would have given me an opportunity of smiting him hip and thigh. Unfortunately I agree with almost everything he has written. But not quite everything. This is largely because we have been engaged on different branches of biology. He knows a lot more than I do about animals; I know more than he does about human physiology and about statistics.

Now how can the biologist help the statesman? He cannot dictate a policy to him. However, he can tell him whether certain statements are true or not; and he can tell him what will be the consequences of certain actions. But the better biologist he is the more often he will say "I don't know". Above all, he can draw the statesman's attention to certain facts and say, "What are you going to do about them?", and he can make him look at old facts from a new angle.

Let me give you an example of what I mean. What is a successful man? Some people mean a man who makes a lot of money; others would say a man who earns the esteem of his fellows,

and is honoured by them. But the biologically successful man is the man who lives a long and healthy life, and leaves behind him a number of healthy children. Now in our society social success and biological success do not go together. The well-to-do classes in the towns live longer than the poor, but they do not have so many children; and even the richest groups in the towns do not live anything like so long as the poor agricultural labourers in the country. That simple fact shows that there is something pretty badly wrong with our society. The ambitious and intelligent men and women deliberately seek an environment which condemns them to premature death and sterility. Don't get away with the idea that our society is peculiar in this respect. In the Middle Ages the human qualities most admired were holiness and chivalry. They condemned their holy men and women to celibacy, and killed off their knights in war. Of course, sanctity and chivalry are not strongly inherited, but heredity probably counts for something in both, and we can see now that our ancestors did their best to breed out these qualities. In the same way we are breeding out the hereditary qualities which we admire.

The same sort of thing is quite frequent in nature. Most of our British beetles can fly—they

do not fly a great deal, but it is worth their while to have wings to take them to suitable environments from time to time. In the island of Madeira about a third of the beetles are wingless. It would seem that the advantages of flight are more than outweighed by the danger of being blown out to sea. In the same way there is reason to believe that in our society the feeble-minded are breeding quicker than the rest of the population. What ought we to do about it? A number of people consider that the feeble-minded, who are said to number three or four hundred thousand in England and Wales, should be sterilized and prevented from breeding. Sterilization is not, of course, castration, but in the case of men at least a trivial operation. Nevertheless it is an interesting fact that few, if any, of the biologists who have made important contributions to our knowledge of heredity have so far supported this programme.

Let us see why not. In the first place feeble-mindedness is a very difficult thing to define, and is not strongly inherited. There are cases where I believe that sterilization would be justifiable. There is a peculiar and terrible form of cancer called glioma which attacks the eyes of children in the first year of their life. Unless one or both eyes are removed they invariably die, after great suffering, before the age of six. When patients

who have been saved from death by removing their eyes have children, the majority of such children suffer like their parents. Here, I believe, is a case where sterilization would be justifiable. So it would in the case of certain other well-defined diseases affecting perhaps a few thousand people in the country.

But feeble-mindedness is nothing so definite. The law defines feeble-minded persons as those who "require care, supervision, or control, for their own protection and that of others". I strongly suspect that I am feeble-minded myself according to this definition. I never can manage to pack all the things I need into a suitcase if I am going away. It may be my collar, my pyjamas, or my toothbrush that I forget, but fortunately I have a legally appointed guardian in the shape of my wife, who supervises my actions. At present anyone can be certified as a mental defective on the words of two doctors and a magistrate, and, since doctors and magistrates are human, they sometimes make mistakes.

You cannot draw a sharp line, as you can in the case of some other inborn defects; nor was Dr. Baker quite correct in suggesting that feeble-mindedness is incurable. I could give examples to the contrary, but I would sooner tell you about my friend Professor X, who is a

very distinguished Fellow of the Royal Society. Up to the age of ten he did not learn to talk, and would have been classified as an imbecile or an idiot. Then an aunt spent a year or so in teaching him to talk, and was quite successful. Or perhaps not quite. He still does not talk as clearly as he might. He will never get a job as a B.B.C. announcer. But he can design apparatus that will solve problems which no amount of talking would solve. I am glad to say that he has two fine children.

Again, though feeble-mindedness runs in families, it is not strongly inherited. Dr. Baker quoted a statement of a certain Dr. Goddard on this subject. I feel sure that he has not read Dr. Goddard's books. Here is a quotation from one of them, about the parents of a feeble-minded child: "Both parents are feeble-minded. The father is very high grade, so that for a considerable time we were much in doubt as to how to classify him. His feeble-mindedness takes the form which makes him noted as being peculiar. He is ignorant, lives alone, but is a good workman, sober, honest and industrious." A good workman, sober, honest, and industrious, but not good enough for Dr. Goddard. It seems to me perfectly monstrous that we should be asked to interfere with our fellows on evidence of this kind. There are no satisfactory

statistics about the inheritance of mental defect. Those which exist seem[1] to show that if we could prevent all mental defectives from breeding it would take some centuries to halve the present proportion of them in our population.

There is another grave objection to a policy of wholesale sterilization. It would certainly not be applied impartially as between different social classes. Let us see how such laws actually work. John Hill was a labourer with five children in the American State of Washington. As the children were half-starved, he stole a number of hams. He was sentenced to imprisonment for not less than six months or more than fifteen years, but the sentence was suspended during his good behaviour. The judge concluded that the family was mentally sub-normal, and suggested that he be sterilized, to which he consented. This may have been an excellent thing for the human race, but does anyone suggest that the same thing would have happened had Mr. Hill been the son of a millionaire?

The programme of the party now in power in Germany includes a number of so-called eugenic measures, intended to check the breeding of various types of defectives, and of

[1] I hope that further research may demonstrate that such measures would be more effective.

persons who are not of "German race". As they describe people who do not share their political opinions as defective—"minderwertig" is the word—it would seem that a large proportion of the German people is regarded as biologically undesirable. In England self-styled eugenists have attacked poor relief, and transitional benefit for the unemployed, on the ground that this class is on the whole congenitally inferior. Now it seems to me that the danger of multiplication of the mentally defective is a real one; but there is a much more pressing and immediate danger. And that is that people of whom Governments do not approve should, on eugenic grounds, be sterilized, segregated or starved. To my mind the attempt to justify such measures on biological grounds is a prostitution of science, far more serious than the manufacture of high explosives, bombing aeroplanes or poisonous gases. We biologists cannot prevent statesmen from doing these things, but we can most emphatically protest against their being done in the name of biology, and in countries where speech is still free we can warn the public against this misuse of our science.

The same sort of pseudo-scientific propaganda goes on about race. It may be that negroes are congenitally inferior to whites, or Italians to

Swedes, but there is no scientific evidence for this. If you could suddenly exchange all the babies in a Kentish village and a South African kraal it is quite likely that the standard of civilization in the village would go down, and that in the kraal would go up. But I don't know; nor does anyone else. Studies of whites and negroes living side by side under like conditions on a West Indian island showed no great differences in intellectual endowment between the two. In most countries the negroes enjoy far worse social and educational advantages than the whites, and no fair comparison can be made. If you want to see which of two cows gives most milk you put them both in the same field; you don't put one in an English meadow and the other on the African veldt. So with men and women.

There is one more reason why a eugenic propaganda which seeks to check the breeding of certain classes is a little misleading. The population in this country is still rising, but fertility has fallen so greatly that it will soon begin to diminish. If you take a hundred new-born English girls and assume that fertility does not fall any farther (which it almost certainly will), you find that, on the average, they will only have about eighty daughters, twenty less than are needed to keep the population steady. Even if medicine

were so perfected as to abolish all deaths under thirty, the population would still diminish.

Now it may be that this country would be better off with a somewhat smaller population, but it is fairly clear that the immediate problem is rather to encourage the propagation of the desirable majority of the nation rather than to discourage that of the undesirable minority. The drop in fertility is not wholly, perhaps not mainly, due to birth control by contraceptives. It has occurred in Italy where contraceptives are effectually forbidden by law, and in Bavarian villages where they are forbidden by religion, as well as in England. Too many of our supposedly advanced thinkers are still thinking in terms of twenty years ago, when fertility was very much higher.

Now this does not mean that nothing should be done to deal with mental defect. The first thing needed is a proper study of it. Think of eye defects causing weak sight. Some are congenital, some acquired; some can be remedied, some cannot. But because short-sight is hereditary in some families we do not suggest that short-sighted people should be sterilized. We realize that they should wear the right kind of spectacles. A proper study of mental defect would perhaps show that some kinds are incurable and strongly hereditary. If so, there would be a case for

sterilization of sufferers from those particular kinds. But it is as unscientific to lump all sorts of feeble-mindedness together, and treat them alike, as it would be to lump together all kinds of weak sight.

What more general eugenic measures could a statesman take? Beyond question the most immediately important eugenic measure is to avoid another war. There may be ethically justifiable wars—I personally think there are—but there are assuredly no biologically justifiable wars. In a modern war the heathiest young men in each fighting nation are killed off. The unhealthy remain behind and beget the next generation. War is a far more serious evil from the eugenic point of view than the multiplication of mental defectives.

Secondly, a eugenical statesman would take steps to raise the birth-rate among all classes except the mentally or physically defective. One main reason for the falling birth-rate is probably that children are felt as an economic burden. This is inevitable under our present economic system. An institution such as hereditary wealth is clearly unsound biologically. For the fewer children you have the more you can leave to each. Moreover, childlessness is rewarded by a rise in the social scale. A man with no children—

or one—is likely to save money; a man with ten cannot do so. Apart from luck, there are two keys to economic success, namely ability and sterility. So long as this is so, ability will tend to marry sterility; and able people to have fewer children than simpletons. The only cure for this state of affairs is some form of endowment of motherhood. I welcome the coming fall in our population because it will probably force the Government to do something concrete for mothers of large families—the most exploited and least politically vocal group in our whole population.

There is a tendency among people who have thought superficially on biology to support our existing social inequalities by analogy with the Darwinian struggle for existence and survival of the fittest. This is a mistake due to the confusion between social and biological success. If able men who became rich usually had large families, and failures who drifted into the slums had small ones, then our economic system would be biologically sound. Actually the opposite is the case. The biologist must welcome economic measures which tend, either to equalize incomes as between different social classes, or to equalize the standard of living as between members of large and small families in the same social class.

I have been dealing with eugenics because

Dr. Baker raised this issue, not because I think that it is the most immediately important application of biology to politics. No eugenic measures could have much effect for a generation. What about the forty million people who are here now? If you are looking after animals the first thing you must think about is their food. A diet which will keep them alive is not good enough to keep them healthy. If you want a stock of rats to grow as well as possible you must feed them properly. But that is not enough. Even though they have the best possible diet from the moment of birth you will not get the best results unless their mothers have been well fed too. It takes two generations before you can wipe out the results of bad feeding. The same is probably true of man, though the evidence is not so complete. You must be very careful of putting down physical defects in a child to bad heredity unless both it and its mother have had an adequate diet.

Do English people get as good a diet as a biologist would prescribe for them? Let us take a family of a man, a wife and three children. Recent calculations[1] show that an adequate diet for them would cost about £1 1s. per week in London. This diet does not include such luxuries as tea and jam, let alone beer, but it is fully adequate

[1] *Week-end Review*, April 1, 1933.

as regards essential dietary constituents. Now it is obvious enough that some million English families have not got a guinea a week to spend on food. I need not quote rates of wages or of unemployment benefit to prove this. If you get less food than this physiological standard, or the same gross amount, but with less of certain desirable constituents such as fruit, greens and liver, you will not die of it. But you will not grow as fully as you might, and you will be more liable to various infections.

A biologically minded Government would regard proper feeding as an important branch of national defence, which it is. For we have had wars with the Dutch, French, Russians, Germans and other nations. But these have been matters of a few years. We are all of us always at war with disease. Even between 1914 and 1918 a great many more English people were killed by the germs of infectious diseases than by our human enemies.

I expect some of you think I am misusing my position as a biologist to make propaganda against our present Government; so to prove that I am trying to be scientific, I am going to talk about some social reforms of which I happen to be in favour, but which cannot be supported on biological grounds. I should like to see agricultural

labourers' wages raised. But this would not make them any healthier. They live about as long as the farmers who employ them. From the merely animal standpoint they are pretty well off. The poor in our towns are not even as well off as well-cared-for animals.

Again, I should personally like to see the school-leaving age raised. But as a biologist I must at once admit that by the time they reach the age of 14 a good many children seem to be pretty incapable of learning anything more. There are large innate inequalities of intelligence, but neither cleverness nor stupidity is confined to any one social group. An educational system designed by a biologist would recognize that inequality. If you have very bright and very dull children in the same class you are being unfair to both. You keep back the bright, and go too fast for the dull. A proper educational system would greatly increase the number of free places and scholarships now available. Even in London there are not enough; almost everywhere else far too few. And such a system would also recognize the fact that not only does the level of intelligence which is finally reached vary, but so does the rate of getting there. The child whose intelligence matures quickest does not always get farthest in the long run. Our existing scholarship system

seems to be designed to pick out precocious children. The hollyhock grows in height ten or twenty times as fast as the oak, but it does not get so far in the long run. We need an educational system that will encourage human oaks as well as human hollyhocks.

Let me put the same point of view rather differently. In any community there must be inequality. We need skilled and unskilled workers, and there must be a few men and women in positions of authority. If everyone were born equal, it would not much matter how the various posts in society were allotted. But we are not born equal, far from it. The best community is that which contains fewest square pegs in round holes, bricklayers who might have been musicians, company directors who, by their own abilities, would never have risen above the rank of clerk. If ability was strictly hereditary, a rigid class system would be biologically justified. But we all know that wise parents may have foolish sons, and conversely. So a system of hereditary classes is not only unjust but inefficient. The greater the equality of opportunity, the greater the likelihood that the right man or woman will be found for any given post. Our society to-day is so complicated that we simply cannot afford to let much of our best human material go to waste, as it does to-day.

But equality of opportunity does not mean equality for those who seize the opportunity and those who miss it. The biologist would demand so much equalization of incomes that no child should be born of a half-starved mother, itself inadequately housed and fed, and denied opportunities because its father had been a failure. He would not demand equal pay for the worker and the slacker, the genius and the dunce. If our society were organized to employ the productive resources which science has given it, there would be enough goods available to secure a satisfactory minimum for all, and a reasonable degree of luxury for those who had succeeded on their own merits. Under such a social system we might perhaps begin to think of restricting the breeding of social failures. To do so under our present system would in many cases merely be to add one injustice to another.

The biologist is not merely concerned with men, but with other animals and plants. Some of these are our friends, some our enemies. Five hundred years ago we still had large-scale enemies, even in England. The last English wolves were killed in the reign of Henry VII. Wolves and wolf-hunting impressed themselves on the people's mind, so that the wolf left its name in such places as Wolverhampton, Wolverton, and Wolvercote.

We still have non-human enemies, but they are smaller. Some, like the louse and the bed-bug, we can see with the naked eye. Others, like the bacteria which cause diphtheria and tuberculosis, we can only see with a microscope. Still others, for example, the causes of measles and smallpox, we cannot see even with a microscope. Now these are our real enemies. The flea, which carries plague, and the louse, which conveys typhus fever, have killed far more men than ever were killed by wolves. But we have never organized against them as we have against wolves, because they have never struck the people's imagination as enemies of man. If they had, we might have towns called Louserhampton and Disinfecton.

The biologist realizes that there is a war on —a very real war of man against disease. Unfortunately, except for the doctors, nurses, research workers, and sanitary workers, such as the municipal dustmen and sewermen, we are mostly non-combatants in this war. We wait till we have been attacked by bacteria, and then call in the doctor. Let us try to imagine what the world would be like if we had biologically educated statesmen backed by a biologically educated public. Do not think that we should all go about in fear and trembling. I do not go about in mortal terror because there are bacteria about, any more than

I did in India because there were tigers and cobras there. But we would no more tolerate lice than we do man-eating tigers. We should say that the proper place for lice was in the Zoo, and we should organize a campaign to make them as extinct in England as the wolf is to-day. It would mean a pretty thorough overhaul of our slums, and about time too! We should no more tolerate a house that harboured bed-bugs than a forest full of tigers.

And the same with infectious diseases. When the virus of smallpox lands on our shores we hunt it down as we should hunt down a foreign invader or a lion. But we do not take the same measures about measles. There are three reasons for this. We have not woken up to the fact that measles kills a great many more people than smallpox or tigers. The effort needed would be very considerable. And above all the effort would have to be international. It would be little use abolishing measles in England if nothing were done about it in France. But just imagine what an international war on disease and parasites would be like. Suppose the peoples and Governments of our own country and the Dominions, Europe, the United States and Japan, agreed to make a real effort to abolish the principal infectious diseases and parasites. We should have to clean ourselves up

and impose a medical inspection and three weeks' quarantine on visitors from outside. We should have our setbacks. A case of diphtheria in Liverpool, and we should rush over armies of experts from the Continent to examine all possible contacts, and throw a ring round the area of infection. An outbreak of measles in Marseilles, and doctors from England and Germany would be flying south to help the French in their fight.

You can say that this is a Utopian idea. But the spirit is there already in international medical and scientific congresses. They cut across the boundaries of international hatred. The last two international physiological congresses were in Boston and Rome. The next is to be in Moscow. There is international rivalry at such congresses; but it is a friendly rivalry. The English try to show the Germans that we have something new to tell them about the nervous system; the Germans show us what they have discovered about digestion. There are no secrets. We are all working for the same ends. And why? Because a discovery in medical science can only be used for the common good. A sick foreigner is of no advantage to this country—on the contrary, he is a possible source of infection. The more we realize the existence of these common enemies of all mankind, the more we shall forget the enmities

between men. That is why the inclusion of biology in our education and our common thinking is one of the most powerful weapons that exist against international hatred.

Some of you think that I should like to hand the world over to an international tyranny of doctors. But wait a bit. Is your doctor really a tyrant? Remember that the world to-day is largely run by business men, that is to say, men who work with a view to getting rich. They may, or may not, enrich others in the process. But the doctors cannot try to corner health. They have a very low death-rate from chronic ailments like cancer and heart disease, which can be tackled in their early stages; but they die in large numbers of acute infections caught from their patients. The pursuit of wealth is generally competitive; that of health must be co-operative. My wealth is not your wealth, but my health *is* your health, because if I fall ill you are likely to contract the same illness.

You see then that biology can do two things for statesmanship. It can urge the statesman to certain definite reforms. But, still more important, it can deflect his mind from issues where one man's good is another man's harm, issues of military and economic rivalry, to issues of health where the interests of different classes and dif-

ferent nations are one. There are higher points of view than the biological. Man is not merely an animal; but he is an animal, and in our political and economic thought we are apt to treat him as a machine for making commodities or a unit in an army. We may desire to educate him or to save his soul; but we differ very sharply about education and salvation. We are all agreed about the difference between a live and a dead man, and mostly about the difference between sickness and health. And the carrying out of biologically desirable reforms would be a wholetime job which would keep statesmen busy for a century. During that century they would have learned to treat their fellow-men not as rivals, but as colleagues. The human race would have become civilized.

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